The Electrochemical Society . . .

119th Meeting

Indianapolis
April 30, May 1, 2, and 3, 1961

LOCAL COMMITTEE

Honorary Chairman
F. C. Mathers

General Chairman
A. M. Max

Co-Chairman
J. M. Booe

Hotel Arrangements
Bernard Agruss

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Registration
R. R. Haberecht

Entertainment
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Plant Visitation and Transportation
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Publicity
Ambrose Smith

Ladies' Program
Mrs. J. M. Booe

Indianapolis Meeting

THE ELECTROCHEMICAL SOCIETY

One Hundred and Nineteenth Meeting

April 30, May 1, 2, and 3, 1961

Sunday through Wednesday

CONDENSED TECHNICAL PROGRAM

Monday, May 1, 1961

Battery—Industrial Electrolytic—Theoretical Electrochemistry (Abstracts 99-103) 9:00 A.M.-11:30 A.M. (Assembly Hall, 8th floor)

Battery—Industrial Electrolytic (Abstracts 104-108) 2:30-4:45 P.M. (Assembly Hall, 8th floor)

Electric Insulation (Abstracts 1-7) 9:00-11:30 A.M.; 2:00-5:00 P.M. (Tower Room, 9th floor)

Electronics-Luminescence (Abstracts 22-35) 9:00 A.M.-12:00 M.; 2:00-4:55 P.M. (Sky Room, 9th floor)

Electronics-Semiconductors (Abstracts 41-52) 9:30 A.M.-12:00 M. (Riley Room, Mezzanine)

Electrothermics and Metallurgy (Abstracts 76-79) 2:00-4:00 P.M. (Florentine Room, Mezzanine)

Industrial Electrolytic—Theoretical Electrochemistry—Battery (Abstracts 99-103) 9:00 A.M.-11:30 A.M. (Assembly Hall, 8th floor)

Industrial Electrolytic—Battery (Abstracts 104-108) 2:30-4:45 P.M. (Assembly Hall, 8th floor)

Theoretical Electrochemistry—Industrial Electrolytic—Battery (Abstracts 99-103) 9:00 A.M.-11:30 A.M. (Assembly Hall, 8th floor)

Theoretical Electrochemistry (Abstracts 127-132) 2:00-5:00 P.M. (Lincoln Room, 14th floor, Sheraton-Lincoln Hotel)

Tuesday, May 2, 1961

Battery—Industrial Electrolytic (Abstracts 109-116) 9:00-11:45 A.M.; 2:00-4:30 P.M. (Assembly Hall, 8th floor)

Electric Insulation (Abstracts 8-15) 9:30-11:30 A.M.; 2:00-4:00 P.M. (Tower Room, 9th floor)

Electronics-Luminescence (Abstracts 36-38) 9:00-11:30 A.M. (Sky Room, 9th floor)

Electronics-Semiconductors (Abstracts 53-65) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Riley Room, Mezzanine)

Electrothermics and Metallurgy (Abstracts 80-88) 9:30-11:30 A.M.; 2:00-4:30 P.M. (Florentine Room, Mezzanine)

Industrial Electrolytic—Battery (Abstracts 109-116) 9:00-11:45 A.M.; 2:00-4:30 P.M. (Assembly Hall, 8th floor)

Theoretical Electrochemistry (Abstracts 133-144) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Lincoln Room, Sheraton-Lincoln Hotel)

Wednesday, May 3, 1961

Electric Insulation (Abstracts 16-21) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Tower Room, 9th floor)

Electronics-Semiconductors (Abstracts 66-75) 9:00 A.M.-11:05 A.M.; 2:00-5:00 P.M. (Riley Room, Mezzanine)

Electrothermics and Metallurgy (Abstracts 89-98) 9:00-11:30 A.M.; 2:00-4:30 P.M. (Florentine Room, Mezzanine)

Industrial Electrolytic (Abstracts 118-126) 9:30-11:45 A.M.; 2:00-4:30 P.M. (Assembly Hall, 8th floor)

Theoretical Electrochemistry (Abstracts 145-160) 9:00 A.M.-12:05 P.M.; 2:00-5:20 P.M. (Chateau Room, Lobby floor, Claypool Hotel)

GENERAL INFORMATION

Convention Headquarters is the Claypool Hotel, 14 North Illinois St., Indianapolis, Ind.

Rates per day for rooms, with bath, are: single rooms, $7.00, 8.00, 9.00; double-bed rooms, $10.50, 11.00; twin-bed rooms, $12.00, 14.00, 16.00, 18.00, 20.00; studio suite, 1 or 2 persons, $13.50; parlor suite, 1 or 2 persons, $20, 25, 30, 75.

Requests for room reservations should be mailed to the Claypool Hotel, 14 North Illinois St., Indianapolis, Ind. If accommodations are not available at the Claypool, that hotel will make suitable reservations for you at a nearby hotel at a comparable price.

BE SURE to state that you will be attending The Electrochemical Society Meeting. If your wife will be attending, be sure to so indicate on your request for reservations.

The Office of the Secretary is Parlor S, Mezzanine.

The Indianapolis Local Section Office is Parlor E, Mezzanine.

The Ladies' Headquarters is the Louis XIV Room, Mezzanine.

REGISTRATION

The Registration Desk will be on the Mezzanine Sunday through Wednesday, April 30 through May 3, 1961.

The registration schedule is:

Sunday, April 30—3:00 to 9:00 P.M.
Monday, May 1—7:30 A.M. to 5:00 P.M.
Tuesday, May 2—8:00 A.M. to 4:00 P.M.
Wednesday, May 3—8:00 A.M. to 12:00 M.

Registration fees are:

Technical Session Registration (Men and Women)	
Member	$ 7.00
Nonmember Speakers and Coauthors	7.00
Nonmembers	20.00*
Student Members	Complimentary
Student Nonmembers	2.00
Wednesday Only	5.00
Ladies' Registration Fee for Social Events	5.00

* If a nonmember fills out an application form and subsequently is elected to membership in the Society, the difference between the nonmember and member registration fee will be applied to his first year's dues. If his membership begins on January 1 he is entitled to the entire differential; if his membership begins on July 1, he is entitled to half the differential.

INFORMATION ABOUT INDIANAPOLIS

Indianapolis, state capital of Indiana, is the most centrally located large city in the United States from the standpoint of population distribution. According to the Federal Bureau of

Census, the exact center of population of the entire country is only a few miles south and west of Indianapolis. Visitors should find many places of interest in and around the city.

Information about places of interest will be available at the Registration Desk and Local Section Headquarters, Parlor E, Mezzanine.

SYMPOSIA

The Electric Insulation Division has scheduled symposia on: Thin Dielectric Films on Monday, May 1; and on Epoxy Resins on Tuesday and Wednesday, May 2 and 3; all sessions in the Tower Room, 9th floor.

The Electronics Division-Luminescence Group has scheduled 3 sessions, two on Monday, one on Tuesday morning; all in the Sky Room, 9th floor.

The Electronics Division-Semiconductor Group has scheduled symposia on: Crystal Growth and Structure, Monday morning; Semiconductor Surfaces, Monday afternoon; Compound Semiconductors, Tuesday morning; Device Processing and Characterization, Tuesday afternoon; Diffusion—Oxidation, Wednesday morning; and Etching, Wednesday afternoon; all sessions in the Riley Room, Mezzanine.

The Electrothermics and Metallurgy Division has scheduled a session on High-Temperature Materials; Extractive Metallurgy on Monday afternoon; and a symposium on Ultrafine Particles, Production on Tuesday; Properties on Wednesday morning; and Particle Size Measurement and Surface Effects on Wednesday afternoon; all sessions in the Florentine Room, Mezzanine.

The Industrial Electrolytic—Theoretical Electrochemistry—Battery Divisions have scheduled a Joint Symposium on Fuel Cells on Monday morning, Assembly Hall, 8th floor.

The Industrial Electrolytic—Battery Divisions have scheduled a Joint Symposium on Fuel Cells Monday afternoon and Tuesday, Assembly Hall, 8th floor.

The Industrial Electrolytic Division has scheduled two general sessions on Wednesday, both in the Assembly Hall, 8th floor.

The Theoretical Electrochemistry Division has scheduled a Symposium on Modern Instrumentation and Techniques of Electrochemical Measurements sponsored by the National Science Foundation—ECS on Monday afternoon, Tuesday, and Wednesday morning; Monday and Tuesday sessions in the Lincoln Room, 14th floor, Sheraton-Lincoln Hotel, Wednesday morning session in the Chateau Room, Lobby floor, Claypool Hotel. The Division has also scheduled a general session Wednesday afternoon in the Chateau Room, Lobby floor, Claypool Hotel.

GENERAL FUNCTIONS

Symposia Chairmen Breakfasts

Special breakfasts will be held for Symposia Chairmen on Monday, Tuesday, and Wednesday, May 1, 2, and 3. On the day on which he presides at a technical session, each Symposium Chairman should be in the Main Dining Room, Lobby floor, **at 7:45 A.M.**

Monday Evening Mixer

There will be a Monday evening social get-acquainted gathering in the Riley Room, Mezzanine, from 8:00 to 10:00 P.M. All those registered for The Electrochemical Society Meeting are invited to attend. Beer, soft drinks, and snacks will be served on a complimentary basis. Admission is by registration badge.

Tuesday Society Luncheon and Business Meeting

The Electrochemical Society Luncheon and Business Meeting will be held at 12:15 P.M. on Tuesday, May 2, in the Travertine Room, 14th floor, Sheraton-Lincoln Hotel, 117 W. Washington St.

Tuesday Evening Reception and Banquet

A reception honoring Dr. and Mrs. Ralph Schaefer will be held at 6:30 P.M. on Tuesday, May 2, in the Riley Room, Mezzanine. Cocktails will be served from 6:30 to 7:30 P.M., followed by dinner. Dr. Schaefer will deliver the Presidential Address.

LADIES PROGRAM

All the ladies are invited to make the Louis XIV Room, Mezzanine, their headquarters during their stay in Indianapolis. Members of the Ladies' Committee will be there to give information and assist in any way they can to make the visit to Indianapolis a pleasant one.

Monday, May 1—Coffee get-acquainted hour from 9:00 to 10:00 A.M. in the Louis XIV Room. At 10:30 A.M. a trip to scenic Brown County has been arranged, with luncheon at Indiana University followed by a tour of the new Lilly Library and points of interest on the campus. Monday evening the ladies are invited to attend the Society Mixer from 8:00 to 10:00 P.M. in the Riley Room, Mezzanine.

Tuesday, May 2—Coffee hour from 9:00 to 10:00 A.M. The rest of the day has been left free. The ladies are invited to attend the Reception and Banquet at 6:30 P.M. in the Riley Room, Mezzanine.

Wednesday, May 3—Coffee hour from 9:00 to 10:00 A.M. At 10:15 A.M. there will be a sight-seeing tour of Indianapolis, luncheon at the Columbia Club, more sightseeing in the afternoon, and at 2:30 a talk at the John Herron Institute.

LUNCHEONS AND BUSINESS MEETINGS

Electric Insulation Division Business Meeting, Monday, May 1, at 9:00 in the Tower Room, 9th floor.

Electronics Division Luncheon and Business Meeting, Monday, May 1, at 12:30 P.M. in the Riley Room, Mezzanine.

Electrothermics and Metallurgy Division Luncheon and Business Meeting, Wednesday, May 3, at 12:30 P.M. in the Empire Room, Mezzanine.

Industrial Electrolytic Division Luncheon and Business Meeting, Wednesday, May 3, at 12:30 P.M. in the Assembly Hall, 8th floor.

Theoretical Electrochemistry Division Luncheon and Business Meeting, Wednesday, May 3, at 12:30 P.M. in the Lincoln Room, 14th floor, Sheraton-Lincoln Hotel.

BOARD AND COMMITTEE MEETINGS

Sunday, April 30, 2:00 P.M.—**Board of Directors,** Empire Room, Mezzanine.

Monday, May 1, 2:00 P.M.—**National Convention Committee,** Parlor T, Mezzanine.

Monday, May 1, 4:30 P.M.—**Council of Local Sections,** Empire Room, Mezzanine.

Monday, May 1, 5:00 P.M.—**Editorial Staff of the Journal,** Parlor D, Mezzanine.

Tuesday, May 2, 5:00 P.M.—**Membership Committee,** Empire Room, Mezzanine.

Wednesday, May 3, 12:15 P.M.—Luncheon Meeting of the **General Chairman of Future Meetings,** Parlor T, Mezzanine.

COST OF VARIOUS FUNCTIONS

(other than registration)

Please buy tickets as early as possible.

Symposia Chairmen Breakfasts	Standard menu prices
Monday Evening Mixer	Complimentary
Division Luncheons	$3.00
Tuesday Society Luncheon	3.00
Tuesday Reception and Banquet	7.00
Ladies functions: Monday trip and luncheon	1.50
Wednesday trip and luncheon	1.00

JOURNALS

Copies of the January, February, March, and April issues of the "Journal of The Electrochemical Society" will be available at the Registration Desk. The price of a single copy of the "Journal" is $1.70 to members and $2.25 to nonmembers.

EXTENDED ABSTRACTS

The Electronics Division is making available an extended abstract booklet containing 1000-word abstracts of most of the papers presented before the Electronics Division at the Indianapolis Meeting. Copies will be available at the Registration Desk or may be obtained about two weeks before the meeting by request to A. E. Hardy, Radio Corp. of America, New Holland Pike, Lancaster, Pa. Price $3.50 with a discount of $00.50 per copy for orders accompanied by payment and requiring no invoice.

DISCUSSION

No recordings will be made of oral discussion. Those contributing to the discussion of a paper and desiring their remarks to be published will be supplied by the symposium chairman with a printed form on which any discussion may be written. These forms should be given to the symposium chairman or to the Managing Editor of the Journal after the session; or they can be mailed to the Managing Editor of the Journal, 1860 Broadway, New York 23, N. Y. The discussion will then be referred to the author for reply. Publication of the discussion and the comments of the author depends on publication of the article in the "Journal".

Written discussion of a published paper should be submitted within two months following publication of the article in the "Journal." A Discussion Section is published semiannually in the "Journal."

EMPLOYMENT POSTERS

Companies which desire to recruit employees at the Indianapolis Meeting will have posters to this effect on a Bulletin Board adjacent to the Registration Desks (see Registration for location). Companies are requested to confine their announcements to this Bulletin Board.

NOTE

Photographing of lantern slides, charts, etc., will be permitted unless specifically prohibited by the speaker. Photo flash and photo floods are prohibited.

1961 FALL MEETING
at the
Statler Hotel
DETROIT, MICHIGAN
October 1, 2, 3, 4, and 5, 1961

Sessions probably will be scheduled on:
Batteries
Corrosion
Electrodeposition (including symposia on Addition Agents and on Electrodeposited Magnetic Films)
Electronics-Semiconductors
Electro-Organic
Electrothermics and Metallurgy

Abstracts for the Detroit Meeting (*not exceeding 75 words in length*) must reach Society Headquarters, 1860 Broadway, New York 23, N. Y., *not later than May 15, 1961* to be included in the Detroit program. Please indicate on abstract for which Division's symposium the paper is to be scheduled and underline the name of the author who will present the paper. No paper will be placed on the program unless one of the authors, or a qualified person designated by the authors, has agreed to present it in person. An author who wishes his paper considered for publication in the JOURNAL should send triplicate copies of the manuscript to the Managing Editor of the "JOURNAL," 1860 Broadway, New York 23, N. Y.

Presentation of a paper at a technical meeting of the Society does not guarantee publication in the "JOURNAL." However, all papers so presented become the property of The Electrochemical Society and may not be published elsewhere, either in whole or in part, unless permission for release is requested of and granted by the Editor. Papers already published elsewhere, or submitted for publication elsewhere, are not acceptable for oral presentation except on invitation by a Divisional program Chairman.

MEETING ROOM SCHEDULE

Meeting	Monday		Tuesday		Wednesday	
	AM	PM	AM	PM	AM	PM
Electric Insulation	A	A	A	A	A	A
Electronics—Luminescence	B	B	B			
—Semiconductor	C	C	C	C	C	C
Electrothermics and Metallurgy—General		D				
—Ultrafine Particles			D	D	D	D
Industrial Electrolytic					E	E
Joint Industrial Electrolytic—Theoretical Electrochemistry—Battery	E					
Joint Industrial Electrolytic—Battery		E	E	E		
Theoretical Electrochemistry		G	G	G	F	F

Claypool Hotel
A—Tower Room, 9th floor
B—Sky Room, 9th floor
C—Riley Room, Mezzanine
D—Florentine Room, Mezzanine
E—Assembly Hall, 8th floor
F—Chateau Room, Lobby floor

Sheraton-Park Hotel
G—Lincoln Room, 14th floor

Technical Program

Indianapolis Meeting

Monday A.M., May 1, 1961

BATTERY — INDUSTRIAL ELECTROLYTIC — THEORETICAL ELECTROCHEMISTRY

Joint Symposium on Fuel Cells, with C. W. Tobias presiding

(ASSEMBLY HALL, 8th floor)

SEE Industrial Electrolytic—Theoretical Electrochemistry—Battery Program.

ELECTRIC INSULATION

9:00 A.M.—Business Meeting of the Electric Insulation Division with A. J. Sherburne presiding

(TOWER ROOM, 9th floor)

Thin Dielectric Films, with C. C. Houtz presiding

(TOWER ROOM, 9th floor)

9:30 A.M.—"Electrolytic Oxide Films" by C. C. Houtz (Abstract No. 1)

10:00 A.M.—"Electrical Properties of Evaporated Aluminum Oxide Films" by E. M. DaSilva and P. White (Abstract No. 2)

10:30 A.M—"Charge Storage Effects in Tantalum Oxide Films" by Rudolf Dreiner (Abstract No. 3)

11:00 A.M.—"Polarity of Tantalum Oxide Printed Capacitors" by N. Schwartz and M. Gresh (Abstract No. 4)

ELECTRONICS—LUMINESCENCE

with E. F. Apple presiding

(SKY ROOM, 9th floor)

9:00 A.M.—"Visible Fluorescence of Rare Earth Activated Phosphors" by S. P. Keller, Invited Speaker (Abstract No. 22)

9:40 A.M.—"Studies of Color Centers Produced in Apatite Halophosphates by Shortwave Ultraviolet Radiation" by Lawrence Suchow (Abstract No. 23)

10:05 A.M.—"Luminescence of Copper-Activated Orthophosphates of the Type $ABPO_4$ (A = Ca, Sr, or Ba and B = Li, Na, or K)" by W. L. Wanmaker and H. L. Spier (Abstract No. 24)

10:25 A.M.—"Crystal Growth and Structural Study of the Barium Titanium Phosphate Phosphor" by D. E. Harrison and G. Shirane (Abstract No. 25)

10:50 A.M.—"Magnesium Lithium Antimonate Phosphors" by R. W. Mooney (Abstract No. 26)

11:15 A.M.—"Particle Size Measurement of Phosphors. A Correlation of Methods" by R. F. Quirk, E. W. Brewster, and R. C. Ropp (Abstract No. 27)

11:40 A.M.—"Measurement of Phosphor Brightness" by J. E. Eby (Abstract No. 28)
12:30 P.M.—Electronics Division Luncheon and Business Meeting, Riley Room, Mezzanine.

ELECTRONICS—SEMICONDUCTORS

Crystal Growth and Structure, with J. E. McNamara presiding

(RILEY ROOM, Mezzanine)

9:30 A.M.—"Epitaxial Growth of Germanium onto Germanium Substrates by Thermal Evaporation" by O. Weinreich, G. Dermit, and C. Tufts (Abstract No. 41)
9:50 A.M.—"Dendritic Growth in Heavily Doped Melts" by R. L. Longini (Abstract No. 42)
10:00 A.M.—"Periodic Growth in Germanium Dendrites" by R. G. Seidensticker and D. R. Hamilton (Abstract No. 43)
10:20 A.M.—Ten-minute intermission
10:30 A.M.—"Distribution Coefficient of Antimony in Silicon from Solvent Evaporation Experiments" by F. A. Trumbore, P. E. Freeland, and R. A. Logan (Abstract No. 44)
10:45 A.M.—"Structure Analysis of Semiconductor Single Crystals by Anomalous Transmission of X-Rays" by G. H. Schwuttke (Abstract No. 45)
11:10 A.M.—Recent News Papers. Titles and short abstracts will be available at the Registration Desk.
12:30 P.M.—Electronics Division Luncheon and Business Meeting in the Riley Room, Mezzanine.

INDUSTRIAL ELECTROLYTIC—THEORETICAL ELECTROCHEMISTRY—BATTERY

Joint Symposium on Fuel Cells, with C. W. Tobias presiding

(ASSEMBLY HALL, 8th floor)

9:00 A.M.—Opening Remarks by J. E. Currey
9:05 A.M.—"Mechanisms of Oxygen Producing Reactions in Molten Carbonate Electrolysis" by G. J. Janz and Fumihiko Saegusa (Abstract No. 99)
9:30 A.M.—"Fuel Cell Thermodynamics" by A. J. deBethune (Abstract No. 100)
10:00 A.M.—"Temperature Coefficients of Electrode Potentials, II. The Second Isothermal Temperature Coefficient" by G. R. Salvi and A. J. deBethune (Abstract No. 101)
10:30 A.M.—"Molten Carbonate as Electrolytes" by G. J. Janz and M. R. Lorenz (Abstract No. 102)
11:00 A.M.—"The DSK System of Fuel Cell Electrodes" by E. Justi and A. Winsel (Abstract No. 103)

MONDAY P. M., MAY 1, 1961

BATTERY—INDUSTRIAL ELECTROLYTIC (cont'd)

Joint Symposium on Fuel Cells (cont'd), with J. E. Currey presiding

(ASSEMBLY HALL, 8th floor)

SEE Industrial Electrolytic—Battery Program.

ELECTRIC INSULATION (cont'd)

Thin Film Dielectrics (cont'd), with R. A. Ruscetta presiding

(TOWER ROOM, 9th floor)

2:00 P.M.—"Dielectric Properties of Evaporated Film Capacitors" by F. S. Maddocks and R. E. Thun (Abstract No. 5)

2:30 P.M.—"Physical and Dielectric Properties of Thin Film SiO_2 Capacitors" by J. A. Minahan, J. L. Sprague, and O. J. Wied (Abstract No. 6)

3:00 P.M.—"Electrical Properties of Evaporated Thin Film SiO Capacitors" by D. B. York (Abstract No. 7)

3:30 P.M.—Round Table Discussion of Thin Film Dielectrics with C. C. Houtz, E. M. DaSilva, R. Dreiner, M. Gresh, F. S. Maddocks, J. A. Minahan, N. Schwartz, J. L. Sprague, R. E. Thun, P. White, O. J. Wied, and D. B. York

ELECTRONICS—LUMINESCENCE (cont'd)

with R. E. Shrader presiding

(SKY ROOM, 9th floor)

2:00 P.M.—"Boron Nitride Phosphors" by W. Lehmann (Abstract No. 29)

2:25 P.M.—"Activator Solubility and Structural Transformations in ZnS:Cu,Cl" by J. W. Nickerson, P. Goldberg, and D. H. Baird (Abstract No. 30)

2:50 P.M.—"ZnS:Cu,Si Phosphors" by A. Wachtel (Abstract No. 31)

3:15 P.M.—"Luminescence of Self-Activated ZnS, ZnSCdS, and ZnSe Phosphors" by R. A. W. Gill and S. Rothschild (Abstract No. 32)

3:40 P.M.—"Decay of Cathodoluminescence and Nonradiative Processes in Manganese-Activated Phosphors" by G. F. J. Garlick and M. Sayer (Abstract No. 33)

4:05 P.M.—"Cathodoluminescent Characteristics of Manganese-Activated Potassium-Magnesium Fluoride" by R. J. Kurtz (Abstract No. 34)

4:30 P.M.—"Transparent Luminescent Films by Solution Spraying" by R. D. Kirk and J. H. Schulman (Abstract No. 35)

ELECTRONICS—SEMICONDUCTORS (cont'd)

Semiconductor Surfaces, with D. Turner presiding

(RILEY ROOM, Mezzanine)

2:10 P.M.—"Electropolishing of N-Type Germanium and P- and N-Type Silicon" by D. L. Klein, G. A. Kolb, L. A. Pompliano, and M. V. Sullivan (Abstract No. 46)

2:30 P.M.—"A Chemical Polishing Technique for Gallium Arsenide" by M. V. Sullivan and L. A. Pompliano (Abstract No. 47)

2:50 P.M.—"Electrolytic Slicing of Germanium" by Sumner Sheff (Abstract No. 48)

3:10 P.M.—"Electron Diffraction Study of Some Crystalline Films on Germanium Surfaces" by J. J. Oberly (Abstract No. 49)

3:30 P.M.—Ten-minute intermission

3:40 P.M.—"Stabilization of Semiconductor Surfaces, I. Chemical Treatment" by G. W. Cullen, J. A. Amick, and D. Gerlich (Abstract No. 50)
3:55 P.M.—"Stabilization of Semiconductor Surfaces, II. Electrical Measurements" by D. Gerlich, G. W. Cullen, and J. A. Amick (Abstract No. 51)
4:10 P.M.—"Stabilization of Germanium Surfaces, III. Chemical Analysis" by J. A. Amick, G. W. Cullen, and D. Gerlich (Abstract No. 52)
4:30 P.M.—Recent News Papers. Titles and short abstracts will be available at the Registration Desk.

ELECTROTHERMICS AND METALLURGY

High-Temperature Materials; Extractive Metallurgy, with E. M. Sherwood presiding

(FLORENTINE ROOM, Mezzanine)

2:00 P.M.—"Coatings for Columbium" by S. T. Wlodek (Astract No. 76)
2:30 P.M.—"High-Temperature Phase Studies in the Tantalum-Boron System between Ta and TaB" by J. M. Leitnaker, M. G. Bowman, and P. W. Gilles (Abstract No. 77)
3:00 P.M.—"Arc-Melting of Intermetallic, Interstitial, and Inorganic Compounds" by R. J. Van Thyne (Abstract No. 78)
3:30 P.M.—"Electrolytic Recovery of Manganese from Sulfurous Leach Liquors" by H. J. Read and J. W. Andrews (Abstract No. 79)

INDUSTRIAL ELECTROLYTIC—BATTERY (cont'd)

Joint Symposium on Fuel Cells (cont'd), with J. E. Currey presiding

(ASSEMBLY HALL, 8th floor)

2:00 P.M.—"Fuel Cells—State of the Art, 1961" by W. Mitchell (Abstract No. 104)
2:30 P.M.—"Thermodynamic Aspects of Electrochemical Fuel Cells" by M. Eisenberg (Abstract No. 105)
3:00 P.M.—Fifteen-minute intermission
3:15 P.M.—"The Fuelox Cell—Solution Variables Affecting Its Performance" by Walter Juda and C. E. Tirrell (Abstract No. 106)
3:45 P.M.—"High-Temperature Methane Fuel Cells" by E. B. Shultz, Jr., L. G. Marianowski, and K. S. Vorres (Abstract No. 107)
4:15 P.M.—"Electrolyte for Low-Temperature Fuel Cells" by K. R. Williams and D. P. Gregory (Abstract No. 108)

THEORETICAL ELECTROCHEMISTRY

Modern Instrumentation and Techniques of Electrochemical Measurements, sponsored by the National Science Foundation—ECS, with P. Ruetschi presiding

(LINCOLN ROOM, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.)

2:00 P.M.—Introductory Remarks by P. Ruetschi
2:05 P.M.—"Electrical Units and Electrochemical Constants" by W. J. Hamer (Abstract No. 127)

2:30 P.M.—"The Design and Use of Potentiostats" by M. Fleischmann (Abstract No. 128)
3:00 P.M.—"Precision Direct Current Regulators" by Karl Eklund (Abstract No. 129)
3:30 P.M.—"Interrupter Techniques" by Ernest Yeager and John Yeager (Abstract No. 130)
4:00 P.M.—"The Use of Operational Amplifiers for Measurement and Control" by C. G. Enke (Abstract No. 131)
4:30 P.M.—"Experimental Difficulties in the Measurement of Low Level Transients of Single Electrodes" by B. D. Cahan (Abstract No. 132)

TUESDAY A.M., May 2, 1961

BATTERY—INDUSTRIAL ELECTROLYTIC (cont'd)

Joint Symposium on Fuel Cells (cont'd), with R. F. Bechtold presiding

(ASSEMBLY HALL, 8th floor)

SEE Industrial Electrolytic—Battery Program.

ELECTRIC INSULATION (cont'd)

Epoxy Resins, with L. J. Frisco presiding

(TOWER ROOM, 9th floor)

9:30 A.M.—"Epoxy Resins from Fats. Monomer Structure and Resin Properties" by W. S. Port (Abstract No. 8)
10:00 A.M.—"A Flame Retardant Epoxy Resin" by R. A. Cass (Abstract No. 9)
10:30 A.M.—"Preparation of Silicone-Epoxy Resins and Their Properties in Glass Cloth Laminates" by S. A. Brady (Abstract No. 10)
11:00 A.M.—"Strength Retentivity of Cured Epoxy Systems in Mineral Acids" by John Delmonte (Abstract No. 11)
12:15 P.M.—Electrochemical Society Luncheon and Business Meeting, Travertine Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

ELECTRONICS—LUMINESCENCE (cont'd)

with Henry Ivey presiding

(SKY ROOM, 9th floor)

9:00 A.M.—"Preparation and Properties of ZnO Phosphors" by A. Pfahnl (Abstract No. 36)
9:25 A.M.—"Electroluminescence in Zinc Sulfide as Due to Minority Carrier Injection" by W. A. Thornton (Abstract No. 37)
9:50 A.M.—"The Dember Effect in ZnS-Type Phosphors" by F. Morehead and A. Fowler (Abstract No. 38)
10:15 A.M.—General Discussion
12:15 P.M.—Electrochemical Society Luncheon and Business Meeting, Travertine Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

ELECTRONICS—SEMICONDUCTORS (cont'd)

Compound Semiconductors, with A. C. Beer presiding

(RILEY ROOM, Mezzanine)

9:00 A.M.—"Precipitation in Gallium Phosphide" by M. Gershenzon, C. J. Frosch, and R. M. Mikulyak (Abstract No. 53)

9:20 A.M.—"Growth Steps on the Surfaces of GaAs Dendrites" by G. R. Booker (Abstract No. 54)

9:40 A.M.—"Dendritic Growth of Indium Antimonide" by N. Albon and A. E. Owen (Abstract No. 55)

10:00 A.M.—"Phase Diagram for the Binary System Indium-Tellurium" by E. G. Grochowski and D. R. Mason (Abstract No. 56)

10:20 A.M.—Ten-minute intermission

10:30 A.M.—"Growth from the Vapor of Large Single Crystals of Lead Selenide of Controlled Composition" by A. C. Prior (Abstract No. 57)

10:50 A.M.—"Single Crystal P-N Junction and Photoconductive Detectors in Lead Selenide" by D. G. Coates, M. Kimmitt, W. D. Lawson, and A. C. Prior (Abstract No. 58)

11:15 A.M.—"Semiconducting Properties of α-Nb_2O_5" by E. H. Greener, D. H. Whitmore, and M. E. Fine (Abstract No. 59)

11:40 A.M.—Recent News Papers. Titles and short abstracts will be available at the Registration Desk.

12:15 P.M.—Electrochemical Society Luncheon and Business Meeting, Travertine Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

ELECTROTHERMICS AND METALLURGY (cont'd)

Ultrafine Particles—Production of Ultrafine Particles, with W. E. Kuhn presiding

(FLORENTINE ROOM, Mezzanine)

9:30 A.M.—Introductory Remarks by W. E. Kuhn

9:45 A.M.—Keynote Address by John Turkevich (Abstract No. 80)

10:00 A.M.—"Ultrafine Metal Oxides by Decomposition of Salts in a Flame" by M. L. Nielsen, P. M. Hamilton, and R. J. Walsh (Abstract No. 81)

10:30 A.M.—"Preparation and Properties of Ultrafine Tungsten Powder" by R. L. Ripley and H. Lamprey (Abstract No. 82)

11:00 A.M.—"Fine Particles Obtained by Evaporation of Metals in an Inert Gas" by Paul Till and John Turkevich (Abstract No. 83)

12:15 P.M.—Electrochemical Society Luncheon and Business Meeting, Travertine Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

INDUSTRIAL ELECTROLYTIC—BATTERY (cont'd)

Joint Symposium on Fuel Cells (cont'd), with R. F. Bechtold presiding

(ASSEMBLY HALL, 8th floor)

9:00 A.M.—"Oxidation of Methyl and Isopropyl Alcohol in a Low-Temperature Fuel Cell" by J. F. Yeager (Abstract No. 109)

9:30 A.M.—"Development of a Portable Air-Breathing Fuel Cell Power-Pack for Field Application" by E. A. Oster and L. E. Chapman (Abstract No. 110)

10:00 A.M.—Fifteen-minute intermission

10:15 A.M.—"Automatic Determination of Fuel Cell Polarization Curves" by W. N. Carson, Jr. (Abstract No. 111)

10:45 A.M.—"Evaluation Criteria for Fuel Cell Systems" by A. M. Moos (Abstract No. 112)

11:15 A.M.—"On CHO Fuel Problems" by W. Vielstich (Abstract No. 113)

12:15 P.M.—Electrochemical Society Luncheon and Business Meeting, Travertine Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

THEORETICAL ELECTROCHEMISTRY (cont'd)

Modern Instrumentation and Techniques of Electrochemical Measurements (cont'd), sponsored by the National Science Foundation—ECS, with Norman Hackerman presiding

(LINCOLN ROOM, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.)

9:00 A.M.—"True Surface Areas of Solid Electrodes" by Norman Hackerman (Abstract No. 133)

9:30 A.M.—"The Single Crystal as a Tool in Electrochemical Research" by A. T. Gwathmey (Abstract No. 134)

10:00 A.M.—"Electrochemical and Adsorption Measurements on Single Crystals" by H. C. Gatos, W. J. LaFleur, and W. W. Harvey (Abstract No. 135)

10:30 A.M.—"Electron Diffraction, Light Microscopy, and X-Ray Analysis of Electrode Surfaces" by Ernest Raub (Abstract No. 136)

11:30 A.M.—"Microscope Techniques for the Study of Electrochemical Processes" by A. C. Simon and E. L. Jones (Abstract No. 137)

12:15 P.M.—Electrochemical Society Luncheon and Business Meeting, Travertine Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

TUESDAY P.M., May 2, 1961

BATTERY—INDUSTRIAL ELECTROLYTIC (cont'd)

Joint Symposium on Fuel Cells (cont'd), with J. C. Cole presiding

(ASSEMBLY HALL, 8th floor)

SEE Industrial Electrolytic—Battery Program

ELECTRIC INSULATION (cont'd)

Epoxy Resins (cont'd), with A. J. Sherburne presiding

(TOWER ROOM, 9th floor)

2:00 P.M.—"Electrical Properties of Epoxide Polymers" by R. W. Warfield and M. C. Petree (Abstract No. 12)

2:30 P.M.—"Mechanical and Electrical Properties of Oxiron Resins" by C. W. Johnston and M. H. Reich (Abstract No. 13)

3:00 P.M.—"Effect of Curing Agent Types and Concentrations on the Mechanical and Electrical Properties of Epoxy Resins" by P. A. Teliha (Abstract No. 14)

3:30 P.M.—"Mechanical and Electrical Properties of New U.C.P.C Epoxy Systems" by F. L. Williamson (Abstract No. 15)

ELECTRONICS—SEMICONDUCTORS (cont'd)

Device Processing and Characterization, with D. R. Mason presiding

(RILEY ROOM, Mezzanine)

2:00 P.M.—"Transistor Potting Material Characteristics" by M. Kowal and E. S. Lukacs (Abstract No. 60)

2:25 P.M.—"Effect of Low Moisture Partial Pressures on Transistor Parameters" by R. J. Gnaedinger, Jr., S. S. Flaschen, M. A. Hall, and E. J. Richez (Abstract No. 61)

2:50 P.M.—"Electrodeposition of Molten Metals and Alloys from Glycerine Solutions" by G. L. Schnable (Abstract No. 62)

3:10 P.M.—Ten-minute intermission

3:20 P.M.—"Anomalous Breakdown Characteristics in Silicon Diffused Junctions" by M. L. McNamara (Abstract No. 63)

3:45 P.M.—"Ambient Studies on the Switching Characteristics of the Avalanche Transistor" by W. T. Eriksen, P. H. Robinson, and H. Vartanian (Abstract No. 64)

4:05 P.M.—"A Very Low Current Controlled Rectifier" by C. W. Heath and W. M. Robinson (Abstract No. 65)

4:30 P.M.—Recent News Papers. Titles and short abstracts will be available at the Registration Desk.

ELECTROTHERMICS AND METALLURGY (cont'd)

Ultrafine Particles—Production of Ultrafine Particles (cont'd), with E. M. Sherwood presiding

(FLORENTINE ROOM, Mezzanine)

2:00 P.M.—"Formation of Elongated Iron Particles by Electrodeposition into Mercury" by F. E. Luborsky (Abstract No. 84)

2:30 P.M.—"Ultrafine Ferrite Particles" by Wm. J. Schuele and V. D. Deetscreek (Abstract No. 85)

3:00 P.M.—"Ultrafine Particles Produced by an Electric Arc" by James Amick and John Turkevich (Abstract No. 86)

3:30 P.M.—"Fine Particle Sizes by Jet Pulverization" by Hugh Boyd (Abstract No. 87)

4:00 P.M.—"Properties and Potentialities of Metal Microcrystals Made by the Freeman Process" by M. W. Freeman, J. H. L. Watson, and Anthony Arrott (Abstract No. 88)

INDUSTRIAL ELECTROLYTIC—BATTERY (cont'd)

Joint Symposium on Fuel Cells (cont'd), with J. C. Cole presiding

(ASSEMBLY HALL, 8th floor)

2:00 P.M.—"The Alkali Metal Amalgam Oxygen Continuous Feed Cell" by E. Yeager (Abstract No. 114)
2:30 P.M.—"Optimization Calculations for Fuel Cell Systems" by J. Van Winkle and W. N. Carson, Jr. (Abstract No. 115)
3:00 P.M.—Fifteen-minute intermission
3:15 P.M.—"The Alcohol Cells. Study of the Successive Oxidation Reactions of the Fuel" by O. Bloch, M. Prigent, and J. C. Balaceanu (Abstract No. 116)
3:45 P.M.—Panel Discussion on Fuel Cells.

THEORETICAL ELECTROCHEMISTRY (cont'd)

Modern Instrumentation and Techniques of Electrochemical Measurements (cont'd), with W. J. Hamer presiding

(LINCOLN ROOM, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.)

2:00 P.M.—"Techniques of Electrochemical Measurements at High Temperatures" by H. A. Laitinen (Abstract No. 139)
2:30 P.M.—"Electrochemical Measurements at High Pressures" by A. Disteche (Abstract No. 140)
3:00 P.M.—"Electron Spin Resonance Measurements in the Study of Electrode Processes" by D. H. Geske (Abstract No. 141)
3:30 P.M.—"A New Method for the Measurement of Fast Ionic Reactions" by H. Strehlow (Abstract No. 142)
4:00 P.M.—"Instrumentation for Electrochemical Calorimetry" by J. M. Sherfey (Abstract No. 143)
4:30 P.M.—"Modern Techniques for Determining Transport Numbers" by F. R. Duke (Abstract No. 144)

WEDNESDAY A.M., May 3, 1961

ELECTRIC INSULATION (cont'd)

Epoxy Resins (cont'd), with A. Gunzenhauser presiding

(TOWER ROOM, 9th floor)

9:00 A.M.—"Effects of Radiation on the Electrical Properties of Epoxy Resins" by J. W. Kallander (Abstract No. 16)
9:30 A.M.—"Physical and Electrical Properties of Epoxy Resins as a Function of Chemical Composition" by C. L. Segal and R. B. Feuchtbaum (Abstract No. 17)
10:00 A.M.—"Comparative Rheological and Fracture Properties of Epoxy Resins in the Glass Transition Range" by D. H. Kaelble (Abstract No. 18)

10:30 A.M.—"Effect of Elevated Temperature on the Physical and Electrical Properties of Epoxy Resin Bonded Glass Fabric Base Laminates" by A. H. Haroldson (Abstract No. 19)

11:00 A.M.—"Properties of Paper-Based and Glass-Based Copper Clad Epoxy Laminates" by H. R. Levine (Abstract No. 20)

11:30 A.M.—"Wire Insulation Life Determined as a Chemical Reaction Rate Function" by E. L. Brancato and F. J. Campbell (Abstract No. 21)

ELECTRONICS—SEMICONDUCTORS (cont'd)

Diffusion—Oxidation, with E. Paskell presiding

(RILEY ROOM, Mezzanine)

9:00 A.M.—"Thermal Oxidation of Germanium" by S. S. Flaschen, D. A. Kallander, and C. M. Lufty (Abstract No. 66)

9:15 A.M.—"Accelerated Thermal Oxidation of Silicon" by D. A. Kallander, S. S. Flaschen, R. J. Gnaedinger, Jr., and C. M. Lufty (Abstract No. 67)

9:40 A.M.—"Studies of the Diffusion of Antimony into Germanium" by J. E. McNamara and H. M. Robertson (Abstract No. 68)

10:05 A.M.—Ten-minute intermission

10:15 A.M.—"Diffusion of Boron in Silicon" by T. H. Yeh and W. Armstrong (Abstract No. 69)

10:40 A.M—"New Techniques for the Measurement of the Impurity-Density Distribution in Diffused-Base Structures" by D. P. Sanders and E. S. Schlegel (Abstract No. 70)

ELECTROTHERMICS AND METALLURGY (cont'd)

Ultrafine Particles (cont'd)—Properties of Ultrafine Particles, with R. L. Reddy presiding

(FLORENTINE ROOM, Mezzanine)

9:00 A.M.—"A Novel Fine Alumina Powder: Fibrillar Boehmite" by John Bugosh, R. L. Brown, J. R. McWhorter, G. W. Sears, and R. J. Sippel (Abstract No. 89)

9:30 A.M.—"Aerosols and Electrical Phenomena" by Bernard Vonnegut and A. W. Doyle (Abstract No. 90)

10:00 A.M.—"Some Characteristics of Arc Vaporized Submicron Particulates" by C. Sheer, J. O. Gibson, and J. D. Holmgren (Abstract No. 91)

10:30 A.M.—"Physical Characteristics and Surface Properties of Pyrogenic Oxides of Silicon and Aluminum" by K. A. Loftman (Abstract No. 92)

11:00 A.M.—"Properties of Submicron Silicon Carbide Produced by Vaporization of Silica and Carbon in the Electric Arc" by W. E. Kuhn (Abstract No. 93)

12:30 P.M.—Electrothermics and Metallurgy Division Luncheon and Business Meeting, Louis XIV Room, Mezzanine.

INDUSTRIAL ELECTROLYTIC

General Session, with W. D. Sherrow presiding

(ASSEMBLY HALL, 8th floor)

9:30 A.M.—"Influence of Some Factors on Cathodic Formation of Hydrogen in the Mercury Cell" by J. H. Entwisle and W. E. Cowley (Abstract No. 118)

10:00 A.M.—"Liquidus Curves for Aluminum Cell Electrolyte, III. Systems Cryolite and Cryolite-Alumina with Aluminum Fluoride and Calcium Fluoride" by Anne Fenerty and E. H. Hollingshead (Abstract No. 119)
10:30 A.M.—Fifteen-minute intermission
10:45 A.M.—"Important Properties of Zirconium and Titanium Boride as Electrode Materials" by R. W. Love and R. A. Alliegro (Abstract No. 120)
11:15 A.M.—"The Uhde Cell and Factors Affecting Large Cell Development and Trends" by F. B. Grosselfinger and J. Schuecker (Abstract No. 121)
12:30 P.M.—Industrial Electrolytic Division Luncheon and Business Meeting, Assembly Hall, 8th floor.

THEORETICAL ELECTROCHEMISTRY (cont'd)

Modern Instrumentation and Techniques of Electrochemical Measurements (cont'd), sponsored by the National Science Foundation—ECS, with E. Yeager presiding

(CHATEAU ROOM, Lobby floor, Claypool Hotel)

9:00 A.M.—"New Developments in the Measurement of Mass Transfer Polarization and Limiting Currents" by C. W. Tobias (Abstract No. 145)
9:30 A.M.—"Rates of Electrode Processes by the Rotating Disk Method" by D. Jahn and W. Vielstich (Abstract No. 146)
10:00 A.M.—"Faradaic Rectification and Electrode Processes, I. Theory" by Mitsugi Senda and Paul Delahay (Abstract No. 147)
10:30 A.M.—"Faradaic Rectification and Electrode Processes, II. Experimental Studies" by Hideo Imai, Mitsugi Senda, and Paul Delahay (Abstract No. 148)
11:00 A.M.—"A-C Methods in Interfacial Electrical Phenomena" by Akira Watanabe (Abstract No. 149)
11:30 A.M.—"Electrokinetic Studies with an X-Y Pulsed Measuring System" by C. H. Presbrey, Jr., and Sigmund Schuldiner (Abstract No. 150)
12:00 M.—Concluding Remarks by P. Ruetschi
12:30 P.M.—Theoretical Electrochemistry Division Luncheon and Business Meeting, Lincoln Room, 14th floor, SHERATON-LINCOLN HOTEL, 117 W. Washington St.

WEDNESDAY P.M., MAY 3, 1961

ELECTRIC INSULATION (cont'd)

Epoxy Resins (cont'd) with L. L. Deer presiding

(TOWER ROOM, 9th floor)

2:00-5:00 P.M.—Round-Table Discussion of Epoxy Resins with S. A. Brady, E. L. Brancato, R. A. Cass, J. Delmonte, A. H. Haroldson, C. W. Johnston, D. H. Kaelble, J. W. Kallander, H. R. Levine, M. C. Petree, W. S. Port, M. H. Reich, C. L. Segal, R. B. Feuchtbaum, P. A. Teliha, R. W. Warfield, and F. L. Williamson

ELECTRONICS—SEMICONDUCTORS (cont'd)

Etching, with H. F. John presiding

(RILEY ROOM, Mezzanine)

2:00 P.M.—"Effect of Different Mechanisms of Minority Carrier Generation on Capacity and Polarization Characteristics of the Silicon/Electrolyte Interface" by P. T. Wrotenbery and R. M. Hurd (Abstract No. 71)

2:20 P.M.—"Chemical Etching Rates of Germanium in the HF-HNO_3-H_2O System" by T. E. Burgess (Abstract No. 72)

2:35 P.M.—"Etching Rate of Indium Alloy Junctions on N-Type Germanium" by William Richardson (Abstract No. 73)

2:55 P.M.—"Preferential Plating and Etching; New Techniques for Microminiature and Other Devices" by W. Rindner and J. M. Lavine (Abstract No. 74)

3:20 P.M.—"Etched Semiconductor Integrated Microcircuit" by W. B. Glendinning (Abstract No. 75)

3:45 P.M.—Ten-minute intermission

3:55 P.M.—Recent News Papers. Titles and short abstracts will be available at the Registration Desk.

ELECTROTHERMICS AND METALLURGY (cont'd)

Ultrafine Particles (cont'd)—Particle Size Measurement and Surface Effects, with C. Sheer presiding

(FLORENTINE ROOM, Mezzanine)

2:00 P.M.—"The Array Method for Sizing Monodisperse Particles" by H. E. Kubitschek (Abstract No. 94)

2:30 P.M.—"Submicron Sizing by X-Ray Technique" by J. J. Martin, J. H. Brown, and P. L. de Bruyn (Abstract No. 95)

3:00 P.M.—"Adsorption Methods of Measuring Surface Areas of Very Fine Particles" by G. F. Agar and P. L. de Bruyn (Abstract No. 96)

3:30 P.M.—"A Kinetic Model for Diffusion Controlled Tarnishing Reactions" by Ralph Carter (Abstract No. 97)

4:00 P.M.—"Use of Submicron Metal and Nonmetal Powders for Dispersion-Strengthened Alloys" by W. S. Cremens (Abstract No. 98)

INDUSTRIAL ELECTROLYTIC (cont'd)

General Session (cont'd) with J. Wood presiding

(ASSEMBLY HALL, 8th floor)

2:00 P.M.—"Platinum Titanium Anodes" by H. B. Berman (Abstract No. 122)

2:30 P.M.—"Studies of the Electrolysis of Sodium Sulfate Solution" by Shinzo Okada, Shiro Yoshizawa, Fumio Hine, Hiromichi Hara, Satoshi Ando, and Isao Kimura (Abstract No. 123)

3:00 P.M.—"On the Estimation of Graphite Packing of Amalgam Decomposer" by Shinzo Okada, Shiro Yoshizawa, and Fumio Hine (Abstract No. 124)

3:30 P.M.—"Theory of Electrolytic Chlorate Formation" by T. R. Beck (Abstract No. 125)

4:00 P.M.—"Graphite Anodes in Brine Electrolysis. Potential Measurements on Horizontal Anodes" by R. C. Coats and Luther Vaaler (Abstract No. 126)

THEORETICAL ELECTROCHEMISTRY (cont'd)

General Session, with Paul Delahay presiding

(CHATEAU ROOM, Lobby floor, Claypool Hotel)

2:00 P.M.—"Effect of Organic Molecules on the Adsorptive Properties of Platinum Electrodes" by Manfred Breiter (Abstract No. 151)

2:20 P.M.—"Characteristic Functions and Parameters in the Theory of Hydrogen Overpotential" by G. W. Castellan (Abstract No. 152)

2:40 P.M.—"Kinetics of Hydrogen Evolution at Zero Hydrogen Partial Pressure" by Sigmund Schuldiner (Abstract No. 153)

3:00 P.M.—"Effects of Electrostatic Fields on the Surface Tension of Salt Solutions" by G. M. Schmid, R. M. Hurd, and E. S. Snavely, Jr. (Abstract No. 154)

3:20 P.M.—"Contact-Potential Olfactometry; Specificity and Sensitivity in Adsorption of Organic Vapors on Solids" by Andrew Dravnieks (Abstract No. 155)

3:40 P.M.—"Measurement of Small Surface Areas by Krypton Adsorption" by Tennyson Smith (Abstract No. 156)

4:00 P.M.—"Continuous Coulometric Analysis of Chlorine Bleach Solutions" by E. L. Eckfeldt and E. R. Kuczynski (Abstract No. 157)

4:20 P.M.—"The Electrokinetic Streaming Potential as a Source of Energy" by R. E. Meredith (Abstract No. 158)

4:40 P.M.—"Polarization Curves of Redox Systems Involving Consecutive Electron Transfers: Some Theoretical Aspects" by R. M. Hurd (Abstract No. 159)

5:00 P.M—"A Model for Electrochemical Reaction Kinetics of Solid-State Phase Transformations in Reversible Electrodes" by G. T. Croft and Donald Tuomi (Abstract No. 160)

Abstracts

ELECTRIC INSULATION

Abstract No. 1

Electrolytic Oxide Films

C. C. Houtz, Bell Telephone Labs., Inc., Murray Hill, N. J.

The nature of the dielectric film in electrolytic capacitors has been a subject of continuing interest over the past fifty years, and it is surprising that not more is known about the nature of these films, their chemical and physical properties, or their mechanism of formation. The increasing economic importance of other metals in the electrolytic capacitor field has renewed interest in the fundamental properties of anodic oxides, and a considerable amount of recent work covers the determination of thickness, dielectric con-

stant, and electrical resistivity. The advent of the diode-capacitor with voltage sensitive properties and the solid electrolytic capacitor developed by Bell Labs. has increased interest in the interface which is the seat of the dielectric, and it appears that we are dealing in both cases with a p-n junction whose properties are not yet well understood. Recent work in the above areas is discussed.

Abstract No. 2

Electrical Properties of Evaporated Aluminum Oxide Films

E. M. DaSilva and **P. White,** International Business Machines Corp., Research Center, Yorktown Heights, N. Y.

This report describes the preparation of aluminum oxide capacitors as thin films of oxide between aluminum electrodes by evaporation techniques. The metal electrodes were prepared by high vacuum evaporation of aluminum, and the oxide dielectric by evaporation from a second aluminum source in an oxygen atmosphere. Values of dielectric constant and dissipation factor of these films have been measured under a variety of conditions and are compared with the electrical properties of aluminum oxide films formed by anodization.

Abstract No. 3

Charge Storage Effects in Tantalum Oxide Films

Rudolf Dreiner, Sprague Electric Co., North Adams, Mass.

Polarization effects are described which have been observed on anodic oxide films of tantalum in an electrolyte when the previously anodically charged film is discharged. The discharge current decreases with time according to an inverse time law, and illumination temporarily decreases and then increases its magnitude. Illumination also affects the residual voltage which arises when the discharge is interrupted by imposing open-circuit conditions.

Abstract No. 4

Polarity of Tantalum Oxide Printed Capacitors

N. Schwartz and **M. Gresh,** Bell Telephone Labs., Inc., Murray Hill, N. J.

The printed capacitor structure [R. W. Berry and D. Sloan, *Proc IRE*, **47**, 1070 (1959)] allows an investigation of the influence of water on the rectification properties of anodic oxide films. These capacitors are partially asymmetric in that their cathodic breakdown voltage is only 10-50% of the anodic value. This asymmetry is probably due to trace amounts of water, since vacuum baking at 100°C results in almost symmetric breakdown voltages equal to the original cathodic value. The cathodic breakdown voltage is strongly dependent on the area of the cathode. For areas of 5×10^{-3}

cm^2 or less, the breakdown voltage approaches the full formation voltage, indicating a dependence on local inhomogeneities in the oxide film. These preliminary results are discussed in reference to current theories on rectification for anodic oxide films.

Abstract No. 5

Dielectric Properties of Evaporated Film Capacitors

F. S. Maddocks and **R. E. Thun,** International Business Machines Corp., Federal Systems Div., Command Control Center, Kingston, N. Y.

The preparation of film capacitors by evaporation is described utilizing the following dielectric materials: silicon monoxide, silicon dioxide, magnesium fluoride, lanthanum fluoride, cerium fluoride, cerium dioxide, and zinc sulfide. The dielectric constants and loss tangents of these materials are presented as functions of the deposition parameters, and the contribution of the lead and condenser plate losses to the apparent loss tangents is shown. The necessary evaporation conditions are discussed for optimizing the dielectric properties of the chosen insulator material. For cerium fluoride, a deposition method consisting essentially in a controlled partial decomposition is described yielding dielectric constants up to $E/Es = 300$ without an undue increase of the capacitor losses.

Abstract No. 6

Physical and Dielectric Properties of Thin Film SiO_2 Capacitors

J. A. Minahan, J. L. Sprague, and **O. J. Wied,** Sprague Electric Co., North Adams, Mass.

Thin film capacitors using SiO_2 as the dielectric material have been prepared by the thermal oxidation of silicon. Physical and optical characteristics of the oxide dielectric are given, and the permittivity and loss tangent of the capacitors are shown as functions of a-c frequency and d-c bias. The dielectric properties are seen to be functions of the conductivity type and resistivity of the substrate silicon.

Abstract No. 7

Electrical Properties of Evaporated Thin Film SiO Capacitors

D. B. York, International Business Machines Corp., Federal Systems Div., Command Control Center, Kingston, N. Y.

The absorption coefficient and transmission of vacuum deposited films of SiO were used as a measure of the reproducibility of the composition of the resulting films. The composition of the films can be reproduced by controlling the evaporation rate and partial pressure of oxygen. Reproducibility of composition does not insure reproducible electrical properties since the surface condition of the electrode material greatly affects the electrical properties.

Abstract No. 8

Epoxy Resins from Fats. Monomer Structure and Resin Properties

W. S. Port, Eastern Regional Research Lab., Philadelphia 18, Pa.

The relationship between the structure of fatty epoxy monomers and the physical properties of the resin produced therefrom with phthalic anhydride was investigated. The principal physical criterion used was the heat distortion temperature (HDT); a secondary basis was the tensile strength. For a series of epoxidized fatty acid esters of comparable structure, HDT was a function of the number of epoxide groups in the monomer or, alternately considered, the number of acyl chains. HDT varied inversely with the distance between epoxy groups and, consequently, it was shown that a pronounced increase in HDT could be achieved by the proper architecture of the epoxy monomers. A comparison was made between HDT of resins derived from epoxidized esters and structurally analogous amides. A significant increase in HDT was produced by the substitution of the amide for the ester structure, but the simple relationship found for the esters did not carry over to the amides. For resins from a series of epoxy diamides, HDT was greater in the old aliphatic, cycloaliphatic, aromatic diamines used in the preparation of the diamide.

Abstract No. 9

A Flame Retardant Epoxy Resin

R. A. Cass, Monsanto Chemical Co., St. Louis, Mo.

The paper discusses a flame retardant epoxy resin produced from tetrachloro bisphenol A and a chemically resistant polyester produced from hydrogenated bisphenol A.

Abstract No. 10

Preparation of Silicone-Epoxy Resins and Their Properties in Glass Cloth Laminates

S. A. Brady, Dow Chemical Corp., Midland, Mich.

Procedures have been developed for copolymerizing silicone and epoxy resins to give new and different laminating resins. The procedure calls for reaction of the silicone and epoxy resins at elevated temperatures in the presence of a solvent and a third reactant. The resulting silicone-epoxy resin gives relatively high structural strengths measured by flexural strength in low-pressure glass cloth laminates. This strength is maintained and in many cases increased after long-term heat aging at 500°F. The nature of the silicone-epoxy resin is dependent on the type and amount of silicone present. At high silicone content, additional strength has been coupled with the good moisture and electrical properties of the silicone. At high epoxy content, better heat age properties have been added to the high strength of the epoxy.

Abstract No. 11

Strength Retentivity of Cured Epoxy Systems in Mineral Acids

John Delmonte, Furane Plastics, Inc., Los Angeles 39, Calif.

Various epoxy resins are cured with both amine and anhydride curing agents, alone and in conjunction with various reactive diluents. The bisphenol A-epichlorohydrin and Novolac type resins and some of the next diepoxides are included in the study. Comparisons are made as to the strength retentivity after long periods of immersion in more important acids and as influenced by cure conditions.

Abstract No. 12

Electrical Properties of Epoxide Polymers

R. W. Warfield and **M. C. Petree,** U.S. Naval Ordnance Lab., Silver Spring, Md.

The electrical volume resistivity, ρ, of several typical epoxide polymers has been determined during isothermal polymerization. After polymerization is complete, ρ has also been determined as a function of temperature. Data so obtained are employed to select the optimum manner in which to conduct a polymerization. Resistivity *vs.* temperature data are also used to determine the glass transition temperature, *Tg*, of a polymer. The relation between *Tg* and the mechanical and electrical properties of a polymer is indicated. Dielectric constants and loss tangents have also been determined over broad temperature and frequency ranges and the results correlated with resistivity measurements. Various results are discussed further in terms of the over-all polymeric structures.

Abstract No. 13

Mechanical and Electrical Properties of Oxiron Resins

C. W. Johnston and **M. H. Reich,** Food Machinery and Chemical Corp., P. O. Box 8, Princeton, N. J.

Oxiron resins are epoxidized polydiolefins made by the Food Machinery and Chemical Corp. These resins contain epoxy and hydroxyl groups as well as ethylenic unsaturation, which imparts to Oxiron resins greater versatility than is possessed by the commercial polyglycidyl polyether resins. Several different types of cure systems may be employed to harden Oxiron resins, namely, aliphatic and aromatic amines with a phenolic catalyst, anhydride-polyols, and maleic anhydride-polyolperoxide. These recipes are covered in the paper, and the mechanical and electrical properties of the resultant castings are reviewed.

Abstract No. 14

Effect of Curing Agent Types and Concentrations on the Mechanical and Electrical Properties of Epoxy Resins

P. A. Teliha, Technical Service Lab., Shell Chemical Co., Union, N. J.

Variations in the electrical and mechanical properties of select epoxy resins arising from changes in the

concentration and type of curing agent have been studied.

Abstract No. 15

Mechanical and Electrical Properties of New U.C.P.C. Epoxy Systems

F. L. Williamson, Union Carbide Plastics Co., Bound Brook, N. J.

The volume of epoxy resin systems used in electrical applications for potting, encapsulation, coating, and as structural components is increasing constantly. New resins are being developed with improved flexibility, heat resistance, electrical properties, and handling characteristics. Selection of the best epoxy system for a typical electrical application may be made from comparative properties of new and established resins. Cured epoxy resins ranging from rubber-like materials to rigid compounds may be achieved through proper selection of resin and hardeners.

Abstract No. 16

Effects of Radiation on the Electrical Properties of Epoxy Resins

J. W. Kallander, U.S. Naval Research Lab., Washington 25, D. C.

Considerations of the usage of epoxy resins to cement solar cells to satellite skins has resulted in the need for knowledge concerning the effects of high-energy radiation on the electrical properties of epoxy resins. Therefore, measurements of the effects of high-energy radiation on the electrical properties of an epoxy adhesive have been made. These measurements included volume resistivity, capacitance, and dissipation factor as function of dosage. They lead to various results including the conclusion that the volume resistivity, the most critical property from the standpoint of the space application, undergoes a very rapid degradation followed by a stable plateau.

Abstract No. 17

Physical and Electrical Properties of Epoxy Resins as a Function of Chemical Composition

C. L. Segal and **R. B. Feuchtbaum,** Hughes Research Labs., Culver City, Calif.

The coefficient of thermal expansion, compressive strength, tensile strength, and infrared spectra of two different epoxy resins were determined as a function of the stoichiometric ratio of the hardener (either an aromatic amine or an aromatic anhydride) to the base resin. The resin/hardener system which yielded the best physical data was then further subjected to moisture conditioning at 96% relative humidity and also to heat aging. Changes in dielectric constant and loss factors were recorded along with any changes in structure as shown by infrared spectra. This investigation

should do much toward determining the relative merit of anhydride-epoxy and amine-epoxy resins as environmentally resistant electrical insulations.

Abstract No. 18

Comparative Rheological and Fracture Properties of Epoxy Resins in the Glass Transition Range

D. H. Kaelble, Minnesota Mining and Manufacturing Co., St. Paul, Minn.

This discussion extends previous description of the dynamic mechanical tensile deformation and tensile fracture properties of epoxies by direct comparison with equivalent properties for elastomers and thermoplastic resins. The essential similarities and differences between epoxies and these comparative polymers are discussed in terms of molecular chemistry and physics.

Abstract No. 19

Effect of Elevated Temperature on the Physical and Electrical Properties of Epoxy Resin Bonded Glass Fabric Base Laminates

A. H. Haroldson, Continental-Diamond Fibre Corp., Newark, Del.

The physical and electrical properties of epoxy resin bonded glass fabric laminates change significantly when subjected to elevated temperatures.

Abstract No. 20

Properties of Paper-Based and Glass-Based Copper Clad Epoxy Laminates

H. R. Levine, Laminated Products Dept., General Electric Co., Coshocton, Ohio

The properties of paper-based and glass-based copper clad epoxy laminates are reported, and the variables involved in the formulation and manufacture of epoxy laminates discussed.

Abstract No. 21

Wire Insulation Life Determined as a Chemical Reaction Rate Function

E. L. Brancato and **F. J. Campbell,** U.S. Naval Research Lab., Washington 25, D. C.

Life *vs.* temperature relationships of wire and cable insulations are needed to provide aircraft and missile engineers with information to design electrical circuits utilizing the minimum wire sizes required to maintain maximum reliability and yet reduce weight and bulk to a minimum. A procedure for obtaining this relationship has been developed, employing the philosophy of functional evaluation and the principles of statis-

tical analysis. Experimental results show that wire insulation deterioration follows a chemical reaction rate relationship as expressed by a variation of the classical Arrhenius equation. In addition, cycling temperature studies verify the application of a relative aging factor formula to convert cyclic aging to the equivalent aging of a single temperature exposure. Advancing studies will probe the mechanisms of deterioration and failures of insulating materials to provide nondestructive test methods which will greatly accelerate the evaluation process.

ELECTRONICS—LUMINESCENCE

Abstract No. 22

Visible Fluorescence of Rare Earth Activated Phosphors

S. P. Keller, Research Center, International Business Machines Corp., Yorktown Heights, N. Y.

Different rare earth ions have been incorporated into various materials such as SrS, $BaTiO_3$, and yttrium gallium garnets. Some optical properties have been determined. Data in terms of the interactions of the rare earth centers and the crystalline lattice are discussed. Such interactions include crystal field and phonon effects. New information that can be obtained using rare earth doping as an experimental tool is discussed also.

Abstract No. 23

Studies of Color Centers Produced in Apatite Halophosphates by Shortwave Ultraviolet Radiation

Lawrence Suchow, (present address: Research Center, International Business Machines Corp., P.O. Box 218, Yorktown Heights, N. Y.), Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

Because many fluorescent lamp phosphors consist of suitably activated alkaline earth halophosphates, and because phosphors receive 1849Å radiation along with 2537Å radiation in lamps, an investigation has been made of the effects of such shortwave ultraviolet radiation on nonluminescent base materials in which it is possible to isolate other electronic effects from those of luminescence. A variety of color centers have been found to be formed. All colors may be bleached thermally and some optically as well. In some cases, bleaching is accompanied by luminescence.

Abstract No. 24

Luminescence of Copper-Activated Orthophosphates of the Type $ABPO_4$ (A = Ca, Sr, or Ba and B = Li, Na, or K)

W. L. Wanmaker and **H. L. Spier,** Light Div., N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands

Activation of orthophosphates of the type $ABPO_4$ with copper gives some efficient phosphors. Especially

good results were obtained with $SrLiPO_4 \cdot Cu$ (λ max. = 4150Å) and $BaLiPO_4 \cdot Cu$ (λ max. = 4600Å). Addition of manganese causes sensitization, giving rise to a red emission peak. The x-ray diagrams of the compounds investigated are given. The properties of compounds with two kinds of alkaline-earth or alkaline ions, respectively, were also studied.

Abstract No. 25

Crystal Growth and Structural Study of the Barium Titanium Phosphate Phosphor

D. E. Harrison and **G. Shirane,** Research Labs., Westinghouse Electric Corp., Pittsburgh 35, Pa.

Examination of single crystals and powder samples of the compound $2BaO:TiO_2:P_2O_5$ revealed a reversible crystallographic inversion at about 1050°C. The two modifications have monoclinic symmetry and can be indexed with very similar lattice constants, but they have quite different line intensities. Powder patterns of both phases have been indexed to 40° 2θ. The high-temperature form has parameters $a_o = 16.578$, $b_o = 5.437$, $c_o = 4.756$, $\beta = 94°0'$, and the low-temperature phase has parameters $a_o = 16.591$, $b_o = 5.435$, $c_o = 4.758$, $\beta = 94°0'$. Single crystal Weissenberg photographs reveal weak spots which cannot be indexed on the primitive unit cell. This substructure can be indexed by doubling the a_o and c_o lattice parameters. Crystals grown from the melt were always twinned, with two types of twinning being distinguished. In one case the b-c plane and in the other case the a-b plane is the twin or composition plane. Fluorescent emission spectra of the high- and low-temperature phases are identical in shape, and they are characterized by a double peak. The spectrum of the high-temperature form lies about 0.02 ev toward longer wavelengths than does the low-temperature form.

Abstract No. 26

Magnesium Lithium Antimonate Phosphors

R. W. Mooney, Chemical and Metallurgical Div., Sylvania Electric Products Inc., Towanda, Pa.

The preparation and properties of phosphors of composition $Mg_3Li_6Sb_2O_{13}$ activated by Mn, U, Ti, Nb, and W are described. It is suggested that the transitions responsible for fluorescence in the Mn- and U-activated phosphors are associated with inner shell electrons while those in the Ti-, Nb-, and W-activated phosphors arise from transitions between the filled 2p band of the oxygen lattice and a d band formed by the overlap of nonbonding d orbitals of neighboring transition metal atoms.

Abstract No. 27

Particle Size Measurement of Phosphors. A Correlation of Methods

R. F. Quirk, Sylvania Electric Products Inc., 75 Sylvan St., Danvers, Mass., **E. W. Brewster,** Sylvania

Electric Products Inc., 60 Boston St., Salem, Mass., and **R. C. Ropp,** Sylvania Electric Products Inc., Towanda, Pa.

Particle size distribution is an important property of phosphors during synthesis and subsequently during bulb coating. The particle size of most commercial lamp phosphors falls within the range of 0.5-50μ. Of the number of methods currently available for making particle size measurements, four are discussed. These are: turbidimetric, centrifugal sedimentation, micromesh sieving, and electronic counting. Measurements on the same materials by the four methods are compared, and the advantages and limitations of each discussed.

Abstract No. 28

Measurement of Phosphor Brightness

J. E. Eby, Sylvania Lighting Products, Inc., 60 Boston St., Salem, Mass.

A new instrument for the measurement of plaque brightness of fluorescent lamp phosphors is described. This instrument is of double-beam design, comparing the brightness of a sample to that of standard phosphor. The reading is obtained from a mechanical beam attenuator, at a point when a null-type signal is obtained from the end-on-type photomultiplier detector. The instrument is capable of making relative brightness measurements with an accuracy of 0.2%. Broad band filters are used to compare brightness of the blue, green, and red emission.

Abstract No. 29

Boron Nitride Phosphors

W. Lehmann, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

Experimental work on the preparation of boron nitride phosphors and some of their properties are described. A wide variety of complex emission spectra could be observed. Impurity activation seems unlikely. The idea is advanced that the luminescence of boron nitride phosphors may be due to contamination of nonluminescent BN with aromatic hydro-boron-nitrides, similar in structure to aromatic hydrocarbons, but every two carbon atoms replaced by one boron and one nitrogen atom.

Abstract No. 30

Activator Solubility and Structural Transformations in ZnS:Cu, Cl

J. W. Nickerson, P. Goldberg, and **D. H. Baird,** General Telephone and Electronics Labs. Inc., Bayside, N. Y.

Chemical analyses and x-ray powder photographs have shown that thermal treatment of hexagonal ZnS:Cu, Cl phosphors in H_2S and He:$ZnCl_2$ atmospheres results in structural transformations and solu-

bility changes of activator and coactivator. The temperature at which these changes occur depends on the copper concentration. One or more of the following factors may be of importance in initiating the transformation of hexagonal to cubic zinc sulfide: (*a*) removal of copper and chloride from the lattice, (*b*) removal of oxygen from the phosphor, and (*c*) exceeding the solubility of copper in the hexagonal modification.

Abstract No. 31

ZnS:Cu, Si Phosphors

A. Wachtel, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

Firing of ZnS + Cu + SiS_2 causes incorporation of Cu and promotes orange fluorescence. Some other tetravalent elements, especially Th, have a similar effect. Possibly, $1Si^{4+} + 2Cu^{1+}$, all at cation sites, may replace $3Zn^{2+}$ in the ZnS lattice. With high concentrations of Cu and Si, a ternary (Zn,Cu,Si)S forms which may show deep-red fluorescence peaked at 840μ.

Abstract No. 32

Luminescence of Self-Activated ZnS, ZnSCdS, and ZnSe Phosphors

R. A. W. Gill and **S. Rothschild,** Mullard Research Labs., Salfords nr. Redhill, Surrey, England

The spectral distribution of the luminescence of self-activated phosphors at low temperatures was found to vary with the concentration of the donor impurity. At low concentrations a band on the short wavelength side of the SA-band with or without some other bands prevailed. It is assumed that the short wavelength band is due to nonassociated coactivator centers. The effects of varying the ratio of ZnS:CdS and of the presence of oxygen on the luminescence at low temperatures were also investigated.

Abstract No. 33

Decay of Cathodoluminescence and Nonradiative Processes in Manganese-Activated Phosphors

G. F. J. Garlick and **M. Sayer,** (present address: University of British Columbia, Vancouver, B. C., Canada) Dept. of Physics, University of Hull, U. K.

Decay constants and emission spectra for single crystals, evaporated layers, and microcrystalline layers of manganese-activated zinc sulfide and silicate and calcium fluoride have been measured for different primary electron energies, etc. Clear evidence of nonradiative processes associated with the single crystal surfaces is found. It is shown that such processes which predominate at low beam penetration are not due to thermal effects or directly to high electron densities. In striking contrast powder layers with large surface areas do not show changes in decay constant with primary electron energy.

Abstract No. 34

Cathodoluminescent Characteristics of Manganese-Activated Potassium-Magnesium Fluoride

R. J. Kurtz, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

The brightness, persistence, and maintenance of light output during life of cathode-ray excited MgF_2:Mn phosphors were studied as a function of (*a*) Mn concentration, (*b*) K:Mg ratio, (*c*) ZnF_2 addition, and (*d*) firing conditions. The emission spectra and brightness-voltage and brightness-current characteristics of these samples also are discussed. (Work supported by Government Contract NObsr-77582.)

Abstract No. 35

Transparent Luminescent Films by Solution Spraying

R. D. Kirk and **J. H. Schulman,** U.S. Naval Research Lab., Washington 25, D. C.

Spraying solutions of zinc chloride or cadmium iodide with activator onto preheated Pyrex or silica glass yields cathodoluminescent films by direct reaction with the glass. The activated silicate films have excellent adherence, good transparency, and, on silica, a brightness comparable to that of evaporated films on Vycor. Films on silica require refiring in air.

Abstract No. 36

Preparation and Properties of ZnO Phosphors

A. Pfahnl, Bell Telephone Labs., Inc., Murray Hill, N. J.

The relative cathodoluminescent intensity I and the absolute value of the decay time τ were determined for the green emission band of several ZnO phosphors. It was found that higher intensities are in general related to longer decay times. The preparation conditions for ZnO phosphors presenting the shortest decay time for a given intensity were then investigated. The form of the decay, temperature dependence of I and τ, aging characteristics, and dependence of the decay time on the exciting current density are also discussed.

Abstract No. 37

Electroluminescence in Zinc Sulfide as Due to Minority Carrier Injection

W. A. Thornton, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

Under the proper experimental conditions, which can be fulfilled in conventional electroluminescent ZnS phosphor powder dispersions in dielectric material or in films, the a-c currents follow the diode equation (for forward bias) $I = I' [\exp (V/V') - 1]$, where V is the applied rms voltage. It is found that $I' \propto \exp (-T'/T)$ where T' is a parameter independent of tem-

perature, and $V' \propto T$. D-C electroluminescence at 2.0 v, again with an exponential current increase, also indicates carrier injection. Arguments for collision ionization are discounted.

Abstract No. 38

The Dember Effect in ZnS-Type Phosphors

F. Morehead and **A. Fowler,** Research Center, International Business Machines Corp., Yorktown Heights, N. Y.

The sign of the more mobile carrier in powder phosphors can be determined conveniently from the direction of a diffusion current pulse produced by a pulse of band gap radiation (Dember effect) onto a conventional electroluminescent cell. Reversals observed in many cases at longer wavelengths are attributed to fast surface states. Along with observations of photoluminescence, electroluminescence, and electrophotoluminescence, this effect gives useful information on phosphor excitation and recombination mechanisms.

ELECTRONICS—SEMICONDUCTORS

Abstract No. 39

(There is no Abstract No. 39.)

Abstract No. 40

(There is no Abstract No. 40.)

Abstract No. 41

Epitaxial Growth of Germanium onto Germanium Substrates by Thermal Evaporation

O. Weinreich, G. Dermit, and **C. Tufts,** Bayside Labs., General Telephone & Electronics Labs. Inc., Bayside 60, N. Y.

An investigation of the crystal structure and electrical properties of germanium films obtained by thermal evaporation of germanium onto germanium single crystals in a vacuum of 10^{-6} mm Hg has been made. The substrate temperatures during deposition were varied between 450° and 900°C. The (110), (111), and (100) planes were exposed to the vapor. Reflection electron diffraction patterns indicate a high perfection of orientation of the deposit when the substrates were heated to 600° and 870°C during evaporation. At substrate temperatures between 450° and 600°C oriented growth was revealed by preferential etching of the films for all planes used in the experiments. When substrates and source materials were appropriately doped, junction formation between substrate and film was observed.

Abstract No. 42

Dendritic Growth in Heavily Doped Melts

R. L. Longini, Research Labs., Westinghouse Electric Corp., Pittsburgh, Pa.

Dendritic growth has been explained in its normally observed form as being the result of nucleation at re-entrant corners. When the melt is heavily doped, however, these re-entrant corners trap segregated impurity thus lowering the melting point locally and removing the supercooling there. Corners sticking out in the melt are thus the most supercooled positions, and growth results from nucleation in the region of these points. (The research reported in this paper was sponsored in part by the Air Force Office of Scientific Research.)

Abstract No. 43

Periodic Growth in Germanium Dendrites

R. G. Seidensticker and **D. R. Hamilton,** Research Labs., Westinghouse Electric Corp., Pittsburgh 35, Pa.

The growth interface of a germanium dendrite is considered to be composed of three regions: the tip where the twin plane mechanism is operative; an intermediate region, described in this paper; and the "H" arm region, where lateral growth takes place. A growth mechanism operative in the intermediate region is discussed, and it is shown that this mechanism provides steady-state oscillation in growth which leads to periodic facet formation on the interface. (This work was supported by the U. S. Air Force through the Electronic Technology Lab. of the Wright Air Development Div.)

Abstract No. 44

Distribution Coefficient of Antimony in Silicon from Solvent Evaporation Experiments

F. A. Trumbore, P. E. Freeland, and **R. A. Logan,** Bell Telephone Labs., Inc., Murray Hill, N. J.

Distribution coefficients have been calculated from Hall effect measurements on heavily doped silicon crystals grown by a solvent evaporation technique from melts containing between 2 and 8.4 at. % antimony. Nearly a twofold decrease in the distribution coefficient (from 0.02 to 0.01) was observed in this concentration range. From the results of this work it appears that near-equilibrium solid solubilities were obtained and that any "facet effect," if present, was small.

Abstract No. 45

Structure Analysis of Semiconductor Single Crystals by Anomalous Transmission of X-Rays

G. H. Schwuttke, Bayside Labs., General Telephone & Electronics Labs., Inc., Bayside 60, N. Y.

Anomalous transmission of x-rays in nearly perfect crystals is strongly decreased in the immediate vicin-

ity of imperfections. This effect has been used by Borrmann (divergent beam technique) and Barth and Hosemann (parallel beam technique) and others to photograph imperfections in single crystals. However, results obtained by these methods are inferior to those results obtained by the x-ray extinction contrast method in which the crystal is scanned. We have improved the parallel beam technique by using a collimator, and as a result we were enabled to obtain high-quality photographs of dislocations and other imperfections in Si, Ge, and GaAs which reveal many details. This technique is simpler and experimentally easier to handle than extinction contrast methods and makes possible the investigation of crystal areas several square centimeters in size without moving the crystal. [The research reported in this paper was sponsored by The Electronics Research Directorate of the Air Force Cambridge Research Center, Air Research and Development Command, under contract No. AF 19-(604)-3482.]

Abstract No. 46

Electropolishing of N-Type Germanium and P- and N-Type Silicon

D. L. Klein, G. A. Kolb, L. A. Pompliano, and **M. V. Sullivan,** Bell Telephone Labs., Inc., Murray Hill, N. J.

A specially designed electropolishing apparatus has produced flat, mirror-like surfaces on both germanium and silicon. The technique makes use of an intensive stirring action between the surface being polished and an inert cathode. For n-type material the holes necessary for the dissolution of the semiconductor can be furnished by strong illumination. The effects of etch composition, current density, resistivity, and the electrical contact to the semiconductor are discussed.

Abstract No. 47

A Chemical Polishing Technique for Gallium Arsenide

M. V. Sullivan and **L. A. Pompliano,** Bell Telephone Labs., Inc., Murray Hill, N. J.

The rate at which gallium arsenide is etched by H_2SO_4-H_2O_2-H_2O mixtures can be accelerated by more than a factor of ten if intensive stirring is employed. By using a flat stirring plate which is moved very close to the gallium arsenide any high points are etched preferentially, and a very smooth flat surface is produced. Etching techniques and etching compositions are described.

Abstract No. 48

Electrolytic Slicing of Germanium

Sumner Sheff, Semiconductor Div., Raytheon Co., 55 Chapel St., Newton 58, Mass.

Thin germanium slices of controlled thickness and orientation have been cut anodically from large n-

and p-type germanium single crystals. The cathode was a small diameter tungsten wire surrounded by a stream of NaOH (aq.) electrolyte. Slicing was accomplished by applying a constant voltage between the cathode wire and the germanium anode, while the latter was moved mechanically through the electrolyte stream. The nature of the germanium surfaces was investigated as a function of the parameters of the experiments.

Abstract No. 49

Electron Diffraction Study of Some Crystalline Films on Germanium Surfaces

J. J. Oberly, Research Div., Raytheon Co., Waltham 54, Mass.

Some crystalline films which appear on single-crystal germanium surfaces have been studied by reflection diffraction of 50 kv electrons. The surface treatments used include electrochemical in NaOH and acetic acid and chemical in CP-4 and NaOH. The possible identification of some of the film constituents as oxides and germanates is discussed. Examples of the partial orientation of some films on the germanium substrate are presented.

Abstract No. 50

Stabilization of Semiconductor Surfaces, I. Chemical Treatment

G. W. Cullen, J. A. Amick, and **D. Gerlich,** RCA Labs., Radio Corp. of America, Princeton, N. J.

In an effort to obtain reproducible and stable semiconductor surfaces a treatment has been developed which is designed to terminate each surface atom with a saturated carbon chain. The rationale for the approach is presented, and the preparative procedure is outlined. The electrical and chemical characteristics of alkylated germanium surfaces are presented in the two following papers.

Abstract No. 51

Stabilization of Semiconductor Surfaces, II. Electrical Measurements

D. Gerlich, G. W. Cullen, and **J. A. Amick,** RCA Labs., Radio Corp. of America, Princeton, N. J.

Measurements of both the trapped charge density in the fast states and the recombination velocity are reported for alkylated germanium surfaces. In the region of surface potential examined, the charge distribution can be described by two discrete surface states. Results show that the surface structure is reproducible, stable, and insensitive to ambients. Measurements of large signal photovoltage and slow states conductivity relaxation are also reported for these surfaces.

Abstract No. 52

Stabilization of Germanium Surfaces, III. Chemical Analysis

J. A. Amick, G. W. Cullen, and **D. Gerlich,** RCA Labs., Radio Corp. of America, Princeton, N. J.

Mass spectrometric and radiotracer techniques have been used to obtain information about the chemical nature of alkylated germanium surfaces. The presence of alkyl groups on the surfaces has been demonstrated. Within experimental accuracy, there is one alkyl group for each germanium atom on a (111) surface. The strength of the bond between the ethyl group and the surface is confirmed by an examination of the chemical stability of the treated surface in different environments.

Abstract No. 53

Precipitation in Gallium Phosphide

M. Gershenzon, C. J. Frosch, and **R. M. Mikulyak,** Bell Telephone Labs., Inc., Murray Hill, N. J.

Microscopic examination of gallium phosphide ingots prepared in graphite boats has revealed the presence of a second phase which is absent after floating zone recrystallization. The precipitated phase is correlated with the carbon that is removed during floating zone purification. Precipitation from crystals saturated with zinc occurs on dislocations and other crystal imperfections, in regions of high strain and near grain boundaries and gives rise to Rayleigh scattering in the visible region of the spectrum.

Abstract No. 54

Growth Steps on the Surfaces of GaAs Dendrites

G. R. Booker, Research Labs., Westinghouse Electric Corp., Pittsburgh 35, Pa.

The methods of optical interference and electron microscopy have been used to study the growth steps occurring on the two main faces of GaAs dendrites. The steps on the Ga face consist of precisely oriented {111} planes, while the steps on the As face do not. Reasons for the difference are given. (This work was supported by the U. S. Air Force through the Electronic Technology Lab. of the Wright Air Development Div.)

Abstract No. 55

Dendritic Growth of Indium Antimonide

N. Albon and **A. E. Owen,** Research Labs., Westinghouse Electric Corp., Pittsburgh 35, Pa.

Recent experiments on the growth of InSb dendrites have revealed growth in the 110 and 321 directions. It has been found that the supercooling of the melt and the twin structure of the seed are both critical for these modes of propagation. The experimental condi-

tions for such growth are described. Photographs of InSb dendrites exhibiting growth in these directions will be shown and some of their characteristic features discussed. (This work was supported by the U. S. Air Force through the Electronic Technology Lab. of the Wright Air Development Div.)

Abstract No. 56

Phase Diagram for the Binary System Indium-Tellurium

E. G. Grochowski and **D. R. Mason,** Dept. of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich.

The phase diagram for the binary system indium-tellurium has been clarified and corrected, particularly in the region near the composition In_2Te_3, because of the potential importance of this material as a semiconductor. Results of this study were obtained by correlating differential thermal analysis (DTA), chemical analyses of zone refined ingots, microscopic analysis, and x-ray determinations. A new phase, In_4Te_7 (ϵ), which transforms peritectic alloy at 625°C, was identified from DTA and chemical analysis of peritectically zone refined ingot. The congruently melting disordered In_2Te_3 (δ) phase (59.8 $\pm$ 0.3 at. % Te) undergoes a eutectoid reaction at 59.5 $\pm$ 0.5 at. % Te and 600° $\pm$ 5°C. Chemical analysis of a zone refined ingot of InTe gave the composition of pure γ-phase as 50.8 at. % Te.

Abstract No. 57

Growth from the Vapor of Large Single Crystals of Lead Selenide of Controlled Composition

A. C. Prior, Royal Radar Establishment, Malvern, England

PbSe crystals have been grown by sublimation using a technique in which almost the whole charge of a few grams is frequently converted into only one single crystal. A substantial measure of control of the Pb:Se ratio of the resulting crystals is achieved by independent control of the partial vapor pressure of selenium during growth, giving carrier concentrations more than an order lower than has been achieved in crystals grown from the melt.

Abstract No. 58

Single Crystal P-N Junction and Photoconductive Detectors in Lead Selenide

D. G. Coates, M. Kimmitt, W. D. Lawson, and **A. C. Prior,** Royal Radar Establishment, Malvern, England

A crystal with a thin surface p-n junction has been grown from the vapor and its photovoltaic properties measured at various temperatures. This detector has high quantum efficiency, but low electrical resistance, which is discussed. A chemical etch for lead selenide has been developed and used for the preparation, from

crystals grown from the vapor, of thin photoconducting specimens with high sensitivity at room temperature.

Abstract No. 59

Semiconducting Properties of α-Nb_2O_5

E. H. Greener (present address: Marquette University, Milwaukee, Wis.), **D. H. Whitmore**, and **M. E. Fine**, Dept. of Materials Science, Northwestern University, Evanston, Ill.

α-Nb_2O_5 has been found to be a metal-excess, n-type semiconductor with near-stoichiometric activation energy of 1.65 ev under constant oxygen partial pressure. The conductivity is related to the ambient oxygen partial pressure by the expression δ = constant $P_{O_2}^{-0.24\pm0.01}$. For dilute concentration of defects, the temperature dependence of the conductivity yielded activation energies of approximately 0.5 ev in the temperature range 100° to —77°C. Equal additions of Mg^{2+} to pure α-Nb_2O_5 were about ten times more effective in lowering the conductivity than Ti^{4+}. The conductivity may be ascribed to a mechanism whereby oxygen ion defect levels are created and electrons are thermally excited from these levels into the conduction band.

Abstract No. 60

Transistor Potting Material Characteristics

M. Kowal and **E. S. Lukacs**, Semiconductor & Materials Div., Radio Corp. of America, Somerville, N. J.

This paper discusses the physical characteristics of some transistor potting materials. Data and testing techniques are given for characteristics such as volume resistivity, moisture content, dielectric strength, and thermal conductivity. The relationship between some of these characteristics and device performance and manufacture is evaluated, and the development of a new method for determining the moisture content of potting materials is described. Results of tests evaluating the effects of sealing ambient conditions and potting-material moisture content on device characteristics are also presented. The development and investigation of a transistor potting material using the methods presented are also discussed.

Abstract No. 61

Effect of Low Moisture Partial Pressures on Transistor Parameters

R. J. Gnaedinger, Jr., **S. S. Flaschen**, **M. A. Hall**, and **E. J. Richez**, Semiconductor Products Div., Motorola, Inc., Phoenix, Ariz.

It has been found that moisture at levels below 0.3% relative humidity has a strong influence on the surface recombination velocity of germanium transistors. By controlling the moisture partial pressure at any given

level within hermetically sealed devices, it is possible to preselect different ranges of final, stabilized device parameters, such as h_{fe} and I_{co}, without changing device fabrication procedure. The discussion includes the manner in which moisture pressure is controlled at levels below 0.1 mm H_2O and a theoretical interpretation of device behavior.

Abstract No. 62

Electrodeposition of Molten Metals and Alloys from Glycerine Solutions

G. L. Schnable, Lansdale Div., Philco Corp., Lansdale, Pa.

Various metals and alloys, including indium, tin, and cadmium alloys used in the fabrication of Surface Barrier and micro-alloyed transistors (SBT, MAT, MADT), have been electrodeposited in molten form on small wires using solutions of metal halides in glycerine. Since high current densities can be employed in molten plating, electrodeposition can be very rapid and binary alloys of metals separated by over 0.6 v in the electromotive series can be codeposited readily.

Abstract No. 63

Anomalous Breakdown Characteristics in Silicon Diffused Junctions

M. L. McNamara, Bell Telephone Labs., Inc., Lauraldale, Pa.

Certain anomalies in the reverse voltage-current characteristics of large area Si diffusion junctions are attributed to circular inclusions apparently formed during diffusion of acceptors into n-type Si. Evidence is presented to show that the boundaries of these inclusions, which form minute p-n junctions, consist of a closed ring of microplasmas. Special distribution of such inclusions are discussed with reference to device fabrication and performance. The roles of surface damage, impurity segregation, and heat treatment in the formation of these inclusions are discussed.

Abstract No. 64

Ambient Studies on the Switching Characteristics of the Avalanche Transistor

W. T. Eriksen, P. H. Robinson, and **H. Vartanian,** Semiconductor Div., Raytheon Co., 55 Chapel St., Newton 58, Mass.

Electrical parameters of the Avalanche Transistor, a silicon npn structure (2N1468), were measured under various ambient conditions, namely, anhydrous NH_3 an electropositive gas, and BF_3 an electronegative gas.

The switching characteristics, *i.e.*, rise and delay time, were measured as a function of gas pressure, and preliminary results indicate they were noticeably affected by the amount of gas present. The delay time decreased as the ammonia pressure increased. The grounded emitter amplification factor (β) varied along with changes in delay time. Reverse currents and breakdown voltages of emitter and collector junctions were also measured as a function of ambient pressure. A mechanism for these changes in switching characteristics also is presented.

Abstract No. 65

A Very Low Current Controlled Rectifier

C. W. Heath and **W. M. Robinson,** Electronics Components Div., General Electric Co., Auburn, N. Y.

The ZJ203 Very Low Current Silicon Controlled Rectifier is housed in the standard JEDEC TO-5 package. This device employs a welded case, glass-to-metal seals, complete absence of soft solders, and a painted external surface for maximum heat dissipation. Design objectives are discussed which have resulted in the development of a PNPN device with very high gate sensitivity, blocking voltages up to 400 v, and extremely uniform characteristics. Processes for producing this all-diffused device are presented in detail. A unique method of silicon pellet bonding is discussed together with the relatively new ultrasonic technique of ohmic contact bonding to silicon. Pellet diffusion and fabrication processes are presented, with slides depicting device construction and characteristics and specialized manufacturing equipment. These and other production processes and tests, also to be discussed, have the prime goal of producing a highly reliable product.

Abstract No. 66

Thermal Oxidation of Germanium

S. S. Flaschen, D. A. Kallander, and **C. M. Lufty,** Semiconductor Products Div., Motorola, Inc., Phoenix, Ariz.

The kinetics of the thermal oxidation of a germanium surface are compared to that of silicon. In the Ge-O_2 system, monoxide volatilization predominates the oxidation reaction above 550°C. At and below 500°C the nonvolatile dioxide forms. If the transport phenomenon is accelerated at this temperature, protective oxide can be formed to thicknesses of 4000Å.

Abstract No. 67

Accelerated Thermal Oxidation of Silicon

D. A. Kallander, S. S. Flaschen, R. J. Gnaedinger, Jr., and **C. M. Lufty,** Semiconductor Products Div., Motorola, Inc., Phoenix, Ariz.

Rate mechanism studies of the thermal oxidation of silicon have led to a low-temperature "accelerated

oxidation" process for formation of the protective surface oxide. Typically 5000Å films can be grown at atmospheric pressure in 1 hr at 600°C. Under these conditions surface channelling or redistribution of p-n doping impurities are absent. 2000-hour aging data under high humidity, power conditions are reported for oxide surface protected, uncanned devices.

Abstract No. 68

Studies of the Diffusion of Antimony into Germanium

J. E. McNamara and **H. M. Robertson,** Materials Research Dept., Semiconductor Products Div., Motorola, Inc., Phoenix, Ariz.

Using a radioactive tracer method, a monolayer of antimony was observed to form on germanium surfaces during certain diffusion processes. The formation and properties of this monolayer are discussed. The rate of out-diffusion of antimony from germanium was measured for a number of external "sink" phases over the temperature range of 600°-700°C. The use of shallow diffused gradients to measure resistivity profiles in thin epitaxial germanium and silicon films is discussed.

Abstract No. 69

Diffusion of Boron in Silicon

T. H. Yeh and **W. Armstrong,** Product Development Labs., International Business Machines Corp., Poughkeepsie, N. Y.

Diffusion of boron into silicon has been investigated over a temperature range of 1150°-1310°C by using an oxidizing carrier gas, 1~50 volume percentage of oxygen with nitrogen, in the two-zone diffusion process. The optical polished silicon surface can be retained after this diffusion process. Wide range of surface concentration, from 10^{17} to 10^{20} atoms/cm^3, can be obtained by varying the impurity (B_2O_3) source temperature. Low diffusion coefficient and a higher activation energy ($\Delta H = 99$ kcal) were obtained than those reported previously.

Abstract No. 70

New Techniques for the Measurement of the Impurity-Density Distribution in Diffused-Base Structures

D. P. Sanders and **E. S. Schlegel,** Philco Corp., C and Tioga St., Philadelphia, Pa.

Inter-relationships between depletion layer thicknesses, electrostatic potentials, and their gradients have been utilized to determine quantitatively the impurity-density distribution of seimconductor material. The technique developed provides a rapid and reproducible means for locating the edge of a diffused layer. The distribution of impurities along a direction perpendicular to the plane of the sample can be cal-

culated from empirical data. The theory is described and data are presented showing the practicality of the methods.

Abstract No. 71

Effect of Different Mechanisms of Minority Carrier Generation on Capacity and Polarization Characteristics of the Silicon/Electrolyte Interface

P. T. Wrotenbery and **R. M. Hurd,** Texas Research Associates, 1701 Guadalupe St., Austin 1, Texas

The effects of light and of an oxidizing redox system on space charge capacities and polarization characteristics of n-type silicon surfaces in various electrolytic environments have been studied. Illumination of the surface, which creates hole-electron pairs throughout the space charge region, gives rise, in the region of inversion, to an increase in both current saturation level and space charge capacity. The presence of the oxidizing couple, which creates holes only at the silicon-electrolyte interface, gives rise to an increased current saturation level, but leaves the capacity unaffected. The effect of the oxidizing couple is not observed in those electrolytic environments in which an oxide film is present, although the effect of light on the space charge capacity is still measurable.

Abstract No. 72

Chemical Etching Rates of Germanium in the $HF\text{-}HNO_3\text{-}H_2O$ System

T. E. Burgess, Sprague Electric Co., North Adams, Mass.

A study of the kinetics of the etching reactions of germanium in $HF\text{-}HNO_3\text{-}H_2O$ solutions has been made under isothermal conditions. Temperature control of the reactions was maintained by employing rapid mechanical stirring of the etching solutions in a controlled temperature bath and was monitored by cementing a thermocouple to the germanium surface before etching. The effect of crystal orientation, resistivity, and solution composition has been investigated. Slower etch rates than previously reported in literature have been measured.

Abstract No. 73

Etching Rate of Indium Alloy Junctions on N-Type Germanium

William Richardson, Sprague Electric Co., North Adams, Mass.

The etching of indium alloy junctions to germanium in etchants of the nitric-hydrofluoric acid system is described. With certain etchants the etching rate of germanium at close vicinity to the alloyed indium is enhanced creating a pronounced moat surrounding the indium dot, while the etching rate of indium alloyed to germanium is retarded compared to that of indium unattached to germanium. These results are discussed

considering local temperature changes during etching and electrochemical potentials arising between indium and germanium.

Abstract No. 74

Preferential Plating and Etching; New Techniques for Microminiature and Other Devices

W. Rindner and **J. M. Lavine,** Research Div., Raytheon Co., Waltham, Mass.

Qualitative aspects of a preferential plating technique are described which permits the fabrication of miniature and microminiature ohmic and doped contacts in complex configurations on a variety of semiconductor materials. These techniques involve the preferential nucleation of chemiplated and electroplated metals on microscopically fine lines scribed on semiconductor surfaces. A supplementary technique involving the preferential chemical etching of similarly scribed lines also is described. Lines of the order of 10^{-4} cm have been plated with a variety of metals including doping elements, and alloyed into germanium and silicon surfaces. These techniques have yielded p-n junctions and offer promise of the fabrication of p-n junction devices at least two orders of magnitude smaller than those currently available. These techniques are also potentially useful in the fabrication of conventionally sized devices such as power transistors. Resistance elements ranging from 10 ohms to 100 kilohms have also been fabricated using preferential plating techniques. Microphotographs of several deposits and various aspects of the film growth will be shown.

Abstract No. 75

Etched Semiconductor Integrated Microcircuit

W. B. Glendinning, U.S. Army Research and Development Lab., Fort Monmouth, N. J.

A fabrication approach to microelectronics systems is described which utilizes semiconductor vapor deposited layers. Simple masking, etchings, and surface finishing techniques are employed upon a multilayer semiconductor slab in such a way as to readily yield an operating microcircuit. An 8-layer silicon sandwich was treated so as to become a 3-terminal circuit capable of yielding an oscillatory output.

ELECTROTHERMICS AND METALLURGY

Abstract No. 76

Coatings for Columbium

S. T. Wlodek, Technology Dept., Union Carbide Metals Co., Niagara Falls, N. Y.

Ten different types of protective coatings for columbium were evaluated for protection against high-temperature oxidation. Although chromium, stainless steel, and Nichrome protected columbium from gross oxida-

tion in the temperature range 950°-1150°C for hundreds of hours, chromium coatings allowed oxygen contamination of the columbium to occur as low as 950°C. A coating of LM-5 (Mo-Si-Cr-B-Al) prevented all reaction for about 1000 hr at 1150° and 100 hr at 1500°C. This coating behaved well under stress and exhibited some self-healing properties and thermal-shock resistance. A duplex coating of LM-5 and a Cb-Ti-Cr-Al-Ni alloy layer retained the static exposure resistance and strain-rate insensitivity of the LM-5 and withstood 30 water-quenches from 1150°C before failure.

Abstract No. 77

High-Temperature Phase Studies in the Tantalum-Boron System between Ta and TaB

J. M. Leitnaker and **M. G. Bowman,** University of California, Los Alamos Scientific Lab., Los Alamos, N. M., and **P. W. Gilles,** Dept. of Chemistry, University of Kansas, Lawrence, Kan.

Phase relationships in the tantalum-boron system between Ta and TaB have been studied. A phase diagram of the solid portion of the system has been determined and is shown. Two three-phase equilibria exist within the system; [1] Ta-Ta_2B-Ta_3B_2 at 2040° ± 30°C, and [2] Ta_2B-Ta_3B_2-TaB at 2180° ± 20°C. The chemical composition of the Ta_2B phase is $Ta_{2.4\pm0.2}B$. The composition of the Ta_3B_2 phase is $Ta_{1.60\pm0.05}B$. The melting point of TaB lies above 2800°C. The extreme slowness of reactions within the system has been investigated qualitatively, and the necessity for seeding at temperatures in the neighborhood of 2000°C has been noted. The results disagree markedly with data previously reported in the literature.

Abstract No. 78

Arc-Melting of Intermetallic, Interstitial, and Inorganic Compounds

R. J. Van Thyne, Metals Research, Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Nonconsumable-electrode arc-melting procedures have been developed to produce high-purity homogeneous compounds. Stoichiometric carbides have been melted. Intermetallic compounds with a volatile constituent may be prepared if close control of charged composition and melting procedures is maintained. Techniques are described that allow metallic oxides with high electrical resistance to be melted.

Abstract No. 79

Electrolytic Recovery of Manganese from Sulfurous Leach Liquors

H. J. Read and **J. W. Andrews,** Dept. of Metallurgy, Pennsylvania State University, University Park, Pa.

Leaching of ferriferous, low-grade manganese ores from central Pennsylvania with sulfur dioxide yields

a manganous sulfate solution low in iron and other readily depositable ions. Electrolytic extraction of manganese was successful only after discovery that the sulfide-ion concentration of the solution is critical. Data on the effects of operating variables on current efficiency are presented.

Abstract No. 80

Keynote Address

John Turkevich, Chemistry Dept., Princeton University, Princeton, N. J.

(No abstract received)

Abstract No. 81

Ultrafine Metal Oxides by Decomposition of Salts in a Flame

M. L. Nielsen, P. M. Hamilton (present address: Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis 66, Mo.), and **R. J. Walsh,** Monsanto Chemical Co., Research and Engineering Div., Dayton 7, Ohio

Decomposition of metal salts atomized in solution within a flame has been investigated as a means of preparing ultrafine metal oxides. Products which have been prepared and characterized include single oxides such as delta-alumina, alpha-ferric oxide, gamma-ferric oxide, titania, zirconia, and others; mixed oxides such as Cr_2O_3-Al_2O_3, NiO-Al_2O_3, CuO-Al_2O_3, and others; and compounds such as $CoAl_2O_4$, $MgFe_2O_4$, and others. Particles are generally spheroidal, with diameters ranging from 0.01 to 5μ, although platelets and hollow spheres are formed under certain conditions.

Abstract No. 82

Preparation and Properties of Ultrafine Tungsten Powder

R. L. Ripley and **H. Lamprey,** Union Carbide Metals Co., P.O. Box 580, Niagara Falls, N. Y.

A process is described for producing tungsten and certain other heavy metal powders in the form of powders of 0.01-0.1μ average particle diameter. Some of the common physical and chemical properties of these materials are discussed, together with data pointing to catalytic and metallurgical uses of the products. Some of the hazards of working with these fine powders are also described.

Abstract No. 83

Fine Particles Obtained by Evaporation of Metals in an Inert Gas

Paul Till and **John Turkevich,** Chemistry Dept., Princeton University, Princeton, N. J.

Ten elements were evaporated in helium of varying pressure and collected at various distances from the source of evaporation. Particle size determinations

were made of the particles collected as a function of the above parameters. These distribution curves were interpreted in terms of nucleation, growth, and aggregation of the fine particles. A mechanism was proposed for both nucleation and growth. The nucleation ability of the atoms was correlated to the physical properties of the element.

Abstract No. 84

Formation of Elongated Iron Particles by Electrodeposition into Mercury

F. E. Luborsky, Research Lab., General Electric Co., Schenectady, N. Y.

The preparation of 100-300Å diameter highly elongated fibers of iron by electrodeposition into mercury is described. The mechanism of formation of these fibers is deduced from direct electron microscopic examination of the structures formed during electrolysis. The relations between the structure of these initial fibers, parameters of formation, and ultimate magnetic properties are discussed.

Abstract No. 85

Ultrafine Ferrite Particles

Wm. J. Schuele and **V. D. Deetscreek,** Labs. for Research and Development, Franklin Institute, Philadelphia 3, Pa.

Ultrafine particles of ferrites (less than 100Å) were prepared by chemical precipitation and grown hydrothermally. Increase in crystallite size as a function of growing time was confirmed by x-ray line broadening and electron diffraction patterns. Magnetic measurements at 25° and —196°C also confirm the increase in particle size as the result of hydrothermal treatment. Data on crystal structure were obtained from x-ray and electron diffraction patterns, and chemical composition by analysis. (This research was supported by the U.S. Air Force under Contract No. AF33(616)-6922 monitored by Wright Air Development Div.)

Abstract No. 86

Ultrafine Particles Produced by an Electric Arc

James Amick and **John Turkevich,** Chemistry Dept., Princeton University, Princeton, N. J.

An electron microscope examination and electron diffraction measurements have been made of 26 elements volatilized in a direct current electric arc. It was found that the oxides so formed showed a definite morphology characteristic of the chemical species. The electron diffraction was used to determine the chemical structure of the fine particles. The particle size distribution obtained in the case of silver was used as a basis for the proposed mechanism of particle formation.

Abstract No. 87

Fine Particle Sizes by Jet Pulverization

Hugh Boyd, Majac Inc., 23 St., Sharpsburg, Pittsburgh 15, Pa.

Jet pulverization is used to produce finer, more precisely controlled particle size distributions by dry methods than are produced by other milling techniques. In this paper, some particle size distribution curves in the range of 80% or more -2μ are discussed and illustrate the production of low and submicron particles. In addition, the principles of jet pulverization to achieve these ends are discussed.

Abstract No. 88

Properties and Potentialities of Metal Microcrystals Made by the Freeman Process

M. W. Freeman, M. W. Freeman Co., 401 David Whitney Bldg., Detroit 26, Mich., **J. H. L. Watson,** Edsel B. Ford Institute for Medical Research, Detroit 2, Mich., and **Anthony Arrott,** Scientific Lab., Ford Motor Co., Dearborn, Mich.

Metal microcrystals made by the Freeman process are different from other crystals of similar size. The properties which contribute to this differentiation and the potential applications which result from unique characteristics of the microcrystals are described as they relate to the wide spectrum of their emphases in medicine, magnetics, polymerization, and strengths of materials. Desirable physical and chemical properties imparted to materials by the microcrystals can be predicted, *e.g.*, when the crystals are used in polymeric complexes, the moduli of elasticity may be increased by 200%. Anticipated tensile strengths for bulk metals are extrapolated from present data as high as 10^6 psi.

Abstract No. 89

A Novel Fine Alumina Powder: Fibrillar Boehmite

John Bugosh, R. L. Brown, J. R. McWhorter, G. W. Sears, and **R. J. Sippel,** Industrial and Biochemicals Dept., E. I. duPont de Nemours & Co., Inc., Wilmington, Del.

An unusual alumina powder has been developed, consisting of porous aggregates of fibrillar particles of boehmite about 50Å wide yet over 1000Å long. A monolayer of acetate groups on the fibrils permits spontaneous dispersion in water to a sol which can be dried to a clear alumina film. Different properties of the powder, characterized by electron micrographs and physical data, are related to possible types of practical uses.

Abstract No. 90

Aerosols and Electrical Phenomena

Bernard Vonnegut and **A. W. Doyle,** Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.

Some fundamental facts of aerosol behavior under the influence of various electrical phenomena are dis-

cussed. The electrical generation of aerosols in described and illustrated. In addition, factors such as methods of charging aerosols, methods of discharging aerosols, maximum charge on aerosols, aerosol mobilities, and methods of measurements are discussed.

Abstract No. 91

Some Characteristics of Arc Vaporized Submicron Particulates

C. Sheer, J. O. Gibson, and **J. D. Holmgren,** Vitro Labs., West Orange Lab., 200 Pleasant Valley Way, West Orange, N. J.

The technique of producing ultrafine powders by vaporization in the high-intensity arc has been applied to a number of refractory materials, including oxides, carbides, and metals. Particle size ranges of the products obtained lie generally between 100 and 1000Å. Following a brief description of the processing technique, a report on the particulate characteristics thus far investigated is presented. Such properties as average size, shape, size distribution, solid state, and surface reactivity have been examined, chiefly by electron microscopy, x-ray diffraction, and sintering tests.

Abstract No. 92

Physical Characteristics and Surface Properties of Pyrogenic Oxides of Silicon and Aluminum

K. A. Loftman, Cabot Corp., Boston, Mass.

Pyrogenic silica and alumina offer the unusual combination of fine particle size, high external surface area, and low apparent density. Determination of particle size, shape, and distribution by electron microscopy is discussed. Evidence of the presence of active surface groups is given and their behavior on heat treatment up to and beyond the sintering temperature. The advantages of using these submicron powders in combination with powdered pigments, chemicals, and plastics are discussed briefly.

Abstract No. 93

Properties of Submicron Silicon Carbide Produced by Vaporization of Silica and Carbon in the Electric Arc

W. E. Kuhn, The Carborundum Co., Research and Development Div., Niagara Falls, N. Y.

Some properties and characteristics of submicron silicon carbide generated by arc vaporization of silica and carbon are described and discussed. The silicon carbide powder consists of a mixture of submicron alpha and beta silicon carbide particles in the shape of plates, fibers, ribbons, and whiskers. The morphology and composition of the arc produced product are interpreted in terms of the mechanism and chemistry of formation. Problems of x-ray, chemical, and particle size measurement are discussed. Its physical, chemical, abrasive, and electrical properties are described and related to possible applications.

Abstract No. 94

The Array Method for Sizing Monodisperse Particles

H. E. Kubitschek, Div. of Biological and Medical Research, Argonne National Lab., Argonne, Ill.

For monodisperse particles the mean diameter may be determined simply, quickly, and with great precision when these particles can be arranged in arrays. The method, which is applicable to particles with diameters below the limit of resolution, has been used for the recalibration of several standard monodisperse polystyrene latexes using an optical microscope. For 1μ particles an accuracy of 10Å is readily attainable. The method also provides an estimate of the variability in particle diameters. (This work was done under the auspices of the U.S.A.E.C.)

Abstract No. 95

Submicron Sizing by X-Ray Technique

J. J. Martin, J. H. Brown (Present address: U.S. Steel Corp., Monroeville, Pa.), and **P. L. de Bruyn,** Dept. of Metallurgy, Massachusetts Institute of Technology, 77 Cambridge Ave., Cambridge 37, Mass.

An apparatus consisting of a bowl-like centrifuge fitted with an x-ray source and detector for absorption measurements was developed and used to examine the size distribution of a brittle material. This technique circumvents the inconsistencies introduced by such factors as Brownian movement, light scattering, and sampling, common to microscopic and other techniques. Experimental data reproducible within about ±5% and in good agreement with theory were obtained for particles as fine as 0.2μ with indications that sizes as fine as 0.05μ or less could have been analyzed. Details of the apparatus, method, and interpretation of data are given.

Abstract No. 96

Adsorption Methods of Measuring Surface Areas of Very Fine Particles

G. F. Agar and **P. L. de Bruyn,** Dept. of Metallurgy, Massachusetts Institute of Technology, 77 Cambridge Ave., Cambridge 37, Mass.

(No abstract received)

Abstract No. 97

A Kinetic Model for Diffusion Controlled Tarnishing Reactions

Ralph Carter, Research Lab., General Electric Co., Schenectady, N. Y.

A model for tarnishing reactions on spherical particles has been developed The oxidation of uniformly sized nickel spheres has been shown to fit this model

to 100% reaction. Previously reported models are inadequate because they do not meet the boundary conditions. The inadequacy of earlier experimental work results because of failure to meet experimentally the conditions imposed by the model.

Abstract No. 98

Use of Submicron Metal and Nonmetal Powders for Dispersion-Strengthened Alloys

W. S. Cremens, Lewis Research Center, Cleveland, Ohio

A mechanical mixing technique for forming dispersion-strengthened alloys of the S.A.P. type is reviewed. Significant parameters for the powders are described and related to the densified alloy microstructure. Various definitions of particle size of powders and of particle spacing in the alloy microstructure are reviewed and evaluated. A summary is given of the current research program on these matters at the NASA Lewis Research Center.

INDUSTRIAL ELECTROLYTIC THEORETICAL ELECTROCHEMISTRY—BATTERY

Abstract No. 99

Mechanisms of Oxygen Producing Reactions in Molten Carbonate Electrolysis

G. J. Janz and **Fumihiko Saegusa,** Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.

A study of oxygen evolution in molten carbonate electrolysis with platinum, gold, and silver anodes is reported. A kinetic analysis of various possible processes contributing to anodic oxygen evolution is presented by extension of the general theory of consecutive reaction rates to molten salt system. In the range of 600°C the process is

$$MO + O^{=} \rightarrow M + O_2 + 2e^{-}$$

is found to be rate determining. At 800°C and higher, processes such as dissolution of metal and reduction of oxides are greatly enhanced.

Abstract No. 100

Fuel Cell Thermodynamics

A. J. deBethune, Chemistry Dept., Yale University, New Haven, Conn.

The work output of a simple fuel cell is $-\Delta G$ of the fuel-oxygen reaction. The "fuel-cell gain" is the ratio of this quantity to the Carnot output of the same amount of fuel and is expressible in terms of fundamental entropy and heat-capacity data. The output of

a regenerative fuel cell cycle obeys Carnot's theorem in integral or differential form. The output of an idealized practical irreversible cycle is also given.

Abstract No. 101

Temperature Coefficients of Electrode Potentials, II. The Second Isothermal Temperature Coefficient

G. R. Salvi and A. J. deBethune, (present address: Dept. of Chemistry, Yale University, New Haven, Conn.) Chemistry Dept., Boston College, Chestnut Hill, Mass.

The second isothermal temperature coefficient of electrode potentials is $\Delta C_p/n\mathbf{F}T$ where ΔC_p is the heat capacity change of the "SHE/Electrode" cell reaction. The mass-action dependence of the second coefficient is given, and values tabulated for 54 standard electrodes, together with the first coefficients [*JES*, **106**, 616 (1959)]. First and second coefficients are related to fundamental entropy and heat capacity data necessary to screening of possible fuel cell reactions.

Abstract No. 102

Molten Carbonate as Electrolytes

G. J. Janz and **M. R. Lorenz,** Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.

The results of an investigation of the properties of surface tension, density, and electrical conductance for molten Li_2CO_3, Na_2CO_3, and K_2CO_3 and some mixtures in the temperature range of 750°-1000°C are reported. The ionic nature of the molten carbonates is examined from the physicochemical criteria based on these properties; the mechanism of electrical transport is considered in the light of current theoretical concepts. Relative to Na_2CO_3-K_2CO_3 mixtures, the surface tensions and partial molal volumes indicate but little deviation from thermodynamic ideality.

Abstract No. 103

The DSK System of Fuel Cell Electrodes

E. Justi and **A. Winsel,** Technische Hochschule, Pockelstrasse 4, Braunschweig, Germany

Elevated operation temperatures of high drain fuel cells can be avoided by increasing the catalytic activity of electrodes. Unfortunately, the most active catalysts, *e.g.*, Raney-metals, do exist inevitably as powders only because of their lattice defects. The authors have developed the "Double Skeleton Katalyst-System" (DSK) to combine the high catalytic activity of powders with mechanical strength and electronic conductivity of bulk metals. DSK-electrodes consist of a microscopic supporting skeleton (sintered carbonyle nickel), containing the submicroscopic skeletons of disordered Raney metal. The authors disclose the preparation of such electrodes for both H_2 and O_2, reaching limiting current densities of 700 ma/cm² at 40 mv polarization at 80°C on H_2-side, and 500 ma/cm² at 500 mv on O_2-side.

INDUSTRIAL ELECTROLYTIC—BATTERY

Abstract No. 104

Fuel Cells—State of the Art, 1961

W. Mitchell, Research Lab., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

(No abstract received)

Abstract No. 105

Thermodynamic Aspects of Electrochemical Fuel Cells

M. Eisenberg, Lockheed Missiles and Space Div., Lockheed Aircraft Corp., Bldg. 102B, Dept. 58-17, P. O. Box 504, Sunnyvale, Calif.

The thermodynamics of galvanic cells is discussed from the point of view of general considerations of free energy and enthalpy changes. Following presentation of the generalized Nernst equation the effects of temperature, pressure, and concentration changes on the reversible open-circuit potential are obtained. Characteristics of fundamental types of electrodes, including gas diffusion electrodes, are described.

The major causes of electrode process irreversibility are considered, and their relation to the efficiency aspects of a fuel cell operation are given. The effect of reaction mechanism of the oxygen electrode in aqueous electrolyte is shown to have a direct effect on the half-cell potential of that electrode. Finally, some specific fuel cells are discussed, and the thermodynamics of a thermally regenerative fuel cell system is presented.

Abstract No. 106

The Fuelox Cell—Solution Variables Affecting Its Performance

Walter Juda and **C. E. Tirrell,** Ionics Inc., 152 Sixth St., Cambridge 42, Mass.

The Fuelox Cell is a regenerative ion-membrane type of fuel cell powered by a bromine solution in the cathode and gaseous hydrogen at the anode. Typical cells have operated at power densities of 2.3 kw/ft^3. Cell performance has been investigated as a function of the following variables: membrane composition, bromine concentration, hydrogen concentration, Br_2 and Br^- diffusion (diffusion from the cathode to the anode), membrane selectivity, Br_2 tolerance of hydrogen electrode.

Abstract No. 107

High-Temperature Methane Fuel Cells

E. B. Shultz, Jr., and **L. G. Marianowski,** Institute of Gas Technology, 17 W. 34th St., Chicago 16, Ill., and **K. S. Vorres,** University of Miami, Coral Gables, Fla.

High-temperature methane fuel cells were constructed with molten carbonate electrolytes held in

ceramic matrices. With methane/steam feed mixtures, porous nickel anodes were used to react methane via primary catalytic reforming and shift reactions on the anode surface. Effects of the major operating variables on performance characteristics of leak-tight cells are presented. Preliminary studies on the use of solid oxide electrolytes to replace carbonates are described.

Abstract No. 108

Electrolyte for Low-Temperature Fuel Cells

K. R. Williams and **D. P. Gregory,** Shell International Petroleum Co. Ltd., St. Helen's Court, Great St. Helen's, London, EC 3, England

From consideration of the function and behavior of the electrodes it is suggested that only strong acids or strong bases can be considered as electrolytes for commercially acceptable low-temperature fuel cells. Since an alkaline electrolyte will not continue to function in the presence of carbon dioxide, only acid electrolytes can be used if carbonaceous fuels are employed. It is therefore suggested that the development of a practical low-temperature hydrocarbon-burning fuel cell is unlikely.

Abstract No. 109

Oxidation of Methyl and Isopropyl Alcohol in a Low-Temperature Fuel Cell

J. F. Yeager, Research Lab., Union Carbide Consumer Products Co., Division of Union Carbide Corp., Parma 30, Ohio

Methyl and isopropyl alcohols may be used as fuels for low-temperature fuel cells having carbon electrodes. Some of the oxidation products of these fuels have been identified. In the case of methyl alcohol the product identification accounts for more than 95% of the final product as potassium formate; in the case of the isopropyl alcohol the product identification accounts for more than 70% of the product as acetone. Polarization data are presented for the methyl alcohol anode.

Abstract No. 110

Development of a Portable Air-Breathing Fuel Cell Power-Pack for Field Application

E. A. Oster and **L. E. Chapman,** Aircraft Accessory Turbine Dept., General Electric Co., Lynn, Mass.

A complete fuel cell power-pack has been developed for transportation as a back pack by a single foot soldier. The 200-w output is obtained at 24 VDC with a power density of approximately 9 w/ft^2 using ambient air as the oxidant. The electrochemical reaction takes place across a cation-exchange polymer-electrolyte which is covered with catalytic electrodes. The hydrogen fuel is produced in an attached generator using a light-weight sodium berohydride and sulfuric acid system.

Abstract No. 111

Automatic Determination of Fuel Cell Polarization Curves

W. N. Carson, Jr., General Engineering Lab., General Electric Co., Schenectady, N. Y.

The design and general operation of a data-logging instrument that is used to determine the polarization curves (power output *vs.* voltage) of from 1 to 10 test cells is described. In the cycle, each cell is tested in turn by being connected to a programmed load sequence; the output current-time, output voltage-time, and output power-output voltage curves are plotted. The relay programmer permits flexible cell loading and use of special polarizing circuits.

Abstract No. 112

Evaluation Criteria for Fuel Cell Systems

A. M. Moos, Patterson Moos Research, Div. of Leesona Corp., 90-28 Van Wyck Expressway, Jamaica 18, N. Y.

A set of criteria permitting evaluation of the fuel cell in terms of a competitive market are described. These criteria can be used to: (*a*) define the research and development guidelines; (*b*) establish the basis for engineering and management decisions for product development and testing; (*c*) compare the utility of the fuel cell system *vs.* conventional power equipment; and (*d*) specify maintenance, fuel costs, and endurance requirements.

Abstract No. 113

On CHO Fuel Problems

W. Vielstich, Institut fur Physikalische Chemie, Universitat Bonn, Wegelerstrasse 12, Bonn Germany

Unlike gaseous and liquid hydrocarbons, CHO fuels can be used in galvanic fuel cells at ambient temperature. Open-circuit potentials are near the hydrogen electrode potential. At higher current densities oscillation phenomena often occur. For the study of reaction mechanism different methods are discussed.

Abstract No. 114

The Alkali Metal Amalgam Oxygen Continuous Feed Cell

Ernest Yeager, Dept. of Chemistry, Western Reserve University, Cleveland 6, Ohio

The anode of the sodium amalgam-oxygen continuous feed cell consists of a vertical steel electrode with liquid amalgam flowing continuously down its surface. Porous carbon electrodes of the semi-lyophobic type have been used as the cathode. The amalgam is produced external to the cell by introducing sodium directly into mercury. The over-all cell reaction is

$4Na + O_2 + 2H_2O \rightarrow 4NaOH$. Performance characteristics are reported for a small single-cell laboratory unit as well as a 5-cell unit of several hundred watt capacity. (Research supported by Office of Naval Research.)

Abstract No. 115

Optimization Calculations for Fuel Cell Systems

J. Van Winkle and **W. N. Carson, Jr.**, General Engineering Lab., General Electric Co., Schenectady, N. Y.

In the design of fuel cell systems, a number of parameters must be assigned before the system can be specified. Usually one of these parameters, the cell operating voltage, can assume a range of values and thus can be used to optimize the system. This paper presents methods for such calculations, using the engineering parameters of the cell and fuel supply and the imposed operational restraints upon the system. The equations for size, weight, or cost are described.

Abstract No. 116

The Alcohol Cells. Study of the Successive Oxidation Reactions of the Fuel

O. Bloch, M. Prigent, and **J. C. Balaceanu,** Institut Francais du Petrole, Rueil-Malmaison, (S-&-O), France

Fuel oxidation in a fuel cell necessarily implies successive chemical reactions, whose nature determines the recoverable potential and intensity. Our studies consist in the identification of the products formed during the oxidation of various alcohols with preparation of the balances: electricity recovered products obtained. Influence of the reaction products on the electric characteristics of the fuel cell is studied, and results are compared with those of simple catalytic dehydrogenation reactions.

INDUSTRIAL ELECTROLYTIC

Abstract No. 117

(There is no Abstract No. 117)

Abstract No. 118

Influence of Some Factors on Cathodic Formation of Hydrogen in the Mercury Cell

J. H. Entwisle and **W. E. Cowley,** Associated Ethyl Co., Ltd., Ellesmere Port, Cheshire, England

The influence of variations in brine pH and concentration, cathodic current density, sodium concentration in amalgam, and movement of the cathode on cathodic hydrogen formation in the mercury cell have been studied in a laboratory cell and by polarographic

methods. Results indicate that the extent of hydrogen ion discharge is controlled by (*a*) transfer of hydrogen ions to the cathode surface, and (*b*) transfer of dissolved sodium from the cathode surface into its bulk.

Abstract No. 119

Liquidus Curves for Aluminum Cell Electrolyte, III. Systems Cryolite and Cryolite-Alumina with Aluminum Fluoride and Calcium Fluoride

Anne Fenerty (present address: Flint, Mich.) and **E. A. Hollingshead,** Aluminium Labs. Ltd., Arvida, Quebec, Canada

Liquidus curves have been determined by means of cooling curves and visual examination of the cooling melt. The binary systems of cryolite with aluminum fluoride and calcium fluoride gave, respectively: peritectic point at 30% aluminum fluoride and 739°C, eutectic point at 40% aluminum fluoride and 694°C, eutectic point at 26% calcium fluoride and 945°C. In the system cryolite-alumina-calcium fluoride the ternary eutectic point was at 2.9% alumina, 21% calcium fluoride and 933°C. (Compositions are in weight %.) Diagrams are given for the cryolite-rich part of the systems cryolite-calcium fluoride, cryolite-alumina-aluminum fluoride, cryolite-alumina-calcium fluoride, and cryolite-alumina-aluminum fluoride-calcium fluoride.

Abstract No. 120

Important Properties of Zirconium and Titanium Boride as Electrode Materials

R. W. Love and **R. A. Alliegro,** Refractories Div., Norton Co., Worcester 6, Mass.

The chemical and physical properties of titanium and zirconium diborides are discussed along with effects imposed by varying the method of manufacture. The possible impact of diborides on the aluminum industry and the historical progress to date are reviewed. The data obtained from an operating laboratory aluminum cell are presented together with photomicrographs of the borides before and after immersion in the cell. Other areas of application in the electrochemical industry are reviewed.

Abstract No. 121

The Uhde Cell and Factors Affecting Large Cell Development and Trends

F. B. Grosselfinger, Hoechst-Uhde Corp., 350 5th Ave., New York 1, N. Y., and **J. Schuecker,** Friedrich Uhde GmbH, Dortmund, Germany

Uhde and other mercury cell designers have been developing cells with higher unit production capacities. This has been attained by increasing both the cathode surface and the current density. These factors,

and an anode adjustment device developed for decreasing cell voltage, directly affect the economics of chlorine production and also have an indirect influence on such economics in connection with plant capacity, rectifier characteristics, cell room size, power and labor costs, and others. This paper briefly discusses these points.

Abstract No. 122

Platinum Titanium Anodes

H. B. Berman, Chemical Div., Englehard Industries, Inc., 113 Astor St., Newark 2, N. J.

(No abstract received)

Abstract No. 123

Studies of the Electrolysis of Sodium Sulfate Solution

Shinzo Okada, Shiro Yoshizawa, and **Fumio Hine,** (present address: Dept. of Chemistry, Western Reserve University, Cleveland 6, Ohio), Dept. of Industrial Chemistry, Kyoto University, Yosida, Kyoto, Japan, and **Hiromichi Hara, Satoshi Ando,** and **Isao Kimura,** Kanegafuchi Spinning Co., Ltd., Tokyo, Japan

The electrolysis of sodium sulfate solution by 1500 amp vertical mercury cell has been investigated. Lead alloy containing 2% Ag and 1% Te was selected as the anode, and fine porous rubber sheets or blue asbestos cloths were used as the diaphram. The concentrations of sulfuric acid and caustic soda obtained were 200-250 g/l H_2SO_4 and 30-45% NaOH, respectively, under the condition of 30 amp/cm^2 of current density by continuous operation. The terminal voltage was less than 5.0 v and the current efficiency and the consumption of the anode were 90-95% and 2-3 mg/amp-hr, respectively.

Abstract No. 124

On the Estimation of Graphite Packing of Amalgam Decomposer

Shinzo Okada, Shiro Yoshizawa, and **Fumio Hine** (present address: Dept. of Chemistry, Western Reserve University, Cleveland 6, Ohio), Dept. of Industrial Chemistry, Kyoto University, Yosida, Kyoto, Japan

The amalgam decomposition tower is a kind of packing column. The height is given by the product of H.T.U. and N.T.U., that is, both H.T.U. and N.T.U. are as follows:

$$\text{H.T.U.} = 1/K \quad M/S \qquad [1]$$

$$\text{N.T.U.} = -\int_{y_0}^{y_1} \frac{dy}{E - \pi_h^{\circ}} \qquad [2]$$

where

$$\frac{1}{K} = \frac{1}{k_A Y} + \frac{1}{k_H} + \frac{1}{k_{FK}} \div \frac{1}{k_H} + \frac{1}{k_{FK}} \qquad [3]$$

H.T.U. is, therefore, controlled by the geometry which occurs between the graphite packing and the amalgam drops. N.T.U. also is determined by the hydrogen overpotential of the graphite. Hence, the performance of the graphite packing may be estimated by those physical and electrochemical characteristics, if they are established empirically.

Abstract No. 125

Theory of Electrolytic Chlorate Formation

T. R. Beck, Electrochemical Section, American Potash & Chemical Corp., P. O. Box 55, Henderson, Nev.

Literature on the electrolytic formation of chlorates was reviewed. Equations were derived for quantitatively expressing current efficiency as a function of cell variables. Current efficiency was correlated in terms of certain dimensionless groups.

Abstract No. 126

Graphite Anodes in Brine Electrolysis. Potential Measurements on Horizontal Anodes

R. C. Coats and **L. E. Vaaler,** Niagara Falls Development Lab., Union Carbon Co., Niagara Falls, N. Y.

A laboratory mercury cell is described in which single electrode potential measurements can be made, denuder materials evaluated, and the effect of anode and brine impurities studied. Potential measurements with a Luggin probe are reported for a variety of anode materials and shapes. The effect of the formation and dispersion of gas bubbles on potential fluctuations is discussed.

THEORETICAL ELECTROCHEMISTRY

Abstract No. 127

Electrical Units and Electrochemical Constants

W. J. Hamer, National Bureau of Standards, Washington, D. C.

Experimental methods used at present to establish the electrical units of current, resistance, and emf are outlined. Considerations are given to the concrete representations (standards) used in maintaining the units, including an evaluation of the over-all accuracy inherent in "absolute" determinations of the units, The role electric units play in modern instrumentation in electrochemistry is discussed from two angles: their direct relation and their indirect role through the medium of electrochemical constants.

Abstract No. 128

The Design and Use of Potentiostats

M. Fleischmann, Chemistry Dept., King's College, University of Durham, Newcastle upon Tyne 1, England

The factors influencing the design of potentiostats are considered. Particular attention is paid to the following points: accuracy to which a desired potential can be maintained; frequency range over which measurements can be made; stabilization of the regulators and the time dependence of the error signal. The way in which these factors are influenced by the cell design and in turn affect the design of the instruments are discussed, and practical circuits are described. Examples of the use of potentiostats in electrochemical measurements are given.

Abstract No. 129

Precision Direct Current Regulators

Karl Eklund, 66 Cliff Ave., Hempstead, N. Y.

A wide range of direct current and voltage regulators may be designed and constructed easily using a simple configuration of an unregulated power supply, a current passing tube, and an operational amplifier. Applications made to low and high current supplies are described. The use of the configuration in a kiloampere regulator operating at 0.2 megawatt and the use of solid-state elements also are discussed.

Abstract No. 130

Interrupter Techniques

Ernest Yeager, Western Reserve University, Cleveland 6, Ohio, and **John Yeager,** Union Carbide Research Center, Parma, Ohio

The interrupter technique for the measurement of polarization is considered in terms of (*a*) general advantages and limitations of the method; (*b*) design and performance characteristics of various circuits using vacuum tubes, thyratrons, transistors, and relays for the switching function; (*c*) apparatus for time-received potential measurements; and (*d*) optimized design of electrochemical cells for use with interrupter techniques.

Abstract No. 131

The Use of Operational Amplifiers for Measurement and Control

C. G. Enke, Princeton University, Princeton, N. J.

The operational amplifier is a high gain, stable, inverting, d-c amplifier. The amplifier controls the current in a feedback path in response to an input current. In conjunction with a few resistors and capacitors, the operational amplifier can be made into a controlled current source, a potentiostat, an isolation

amplifier, an electrometer, an oscillator, a sweep generator, and many other devices, all having very high accuracy, stability, and response speed.

Abstract No. 132

Experimental Difficulties in the Measurement of Low Level Transients of Single Electrodes

B. D. Cahan, Research Div., Philco Corp., Philadelphia 34, Pa.

Theoretical and practical treatments of experimental measurements of single electrodes using pulses with rise times less than 1.0 μsec are given. The effects of ground loops, capillary size and placement, and input amplifier loading on the behavior of square-wave, step-function, interrupter, and pulse techniques are discussed. Circuitry for extremely high input impedance ($<$0.1 $\mu\mu$f), 10 mμsec rise time pre-amps, and 10 mμsec interrupters is presented in the light of the above.

Abstract No. 133

True Surface Areas of Solid Electrodes

Norman Hackerman, Dept. of Chemistry, University of Texas, Austin 12, Texas

This paper considers some of the more effective methods for determining the actual areas of solid surfaces. It is presumed that the surface to be seen does not exist in deep, narrow pores. It is also noted that electrode area is not wholly a function of the solid, *i.e*, it depends to a large extent on the size of the particle of interest in the solution phase. This follows from the fact that it is really the accessible area which is important. Microscopic measurements, electron and optical; differential capacity measurements; adsorption from solution, both by equilibrium and by rate studies; and adsorption of gases are considered. It is concluded that within the limitation of proper assignment of areas occupied per molecule of adsorbate the last of these methods provides the best information.

Abstract No. 134

The Single Crystal as a Tool in Electrochemical Research

A. T. Gwathmey, Dept. of Chemistry, University of Virginia, Charlottesville, Va.

Since the single crystal is the unit of which crystalline solids are composed, it offers a special opportunity for the study of many variables which control the electrochemistry of solid surfaces. The influence of surface structure, including crystal face, atomic steps, and imperfections, may be investigated, and little information has hitherto been available on the effects of these structural factors. Techniques for making such studies and the significance of the results obtained are discussed.

Abstract No. 135

Electrochemical and Adsorption Measurements on Single Crystals

H. C. Gatos, W. J. LaFleur, and **W. W. Harvey,** Lincoln Lab., Massachusetts Institute of Technology, Lexington 73, Mass.

An apparatus is described for electrochemical studies on single crystals under controlled environmental conditions. By employing radioactive tracers adsorption, desorption, and exchange reaction kinetics can be studied concurrently with the electrochemical measurements. The amount adsorbed is measured *in situ* with a scintillation counter. The surface of the single-crystal electrode can be cleaned and characterized after mounting in position, and the composition of the electrolyte can be altered without disturbing the sample under study. In addition, the effects of illumination on the surface behavior of single crystals of semiconductors can be investigated conveniently. Preliminary measurements on germanium single crystals are presented indicating the salient points and limitations of the apparatus.

Abstract No. 136

Electron Diffraction, Light Microscopy, and X-Ray Analysis of Electrode Surfaces

Ernest Raub, Forschungsinstitut fur Edelmetalle und Metallchemie, Schwabisch Gmund, Fernruf 3913, Stuttgart, Germany

X-ray analysis, electron diffraction, electron and light microscopy are used to investigate the surface of electrodes at anodical treatment (formation of anodic oxide layers, changes of the surface structure by electrolytic polishing) and at cathodic deposition. Of special interest are the crystal growth without and under the influence of cathodic adsorption films and the structure of electrodeposited metals and alloys. Modern techniques and the possibilities of their application are discussed for some practical instances.

Abstract No. 137

Microscope Techniques for the Study of Electrochemical Processes

A. C. Simon and **E. L. Jones,** U.S. Naval Research Lab., Washington 25, D. C.

The use of the microscope for the study of electrode processes is discussed. Various special techniques and apparatus are discussed that have been used successfully by the authors in the study of corrosion, cell reactions, and the analysis of electrode products. Methods are given for preparing samples for examination, for constructing various types of microcells, and for obtaining analytical samples from very small areas.

(There is no Abstract No. 138)

Abstract No. 139

Techniques of Electrochemical Measurements at High Temperatures

H. A. Laitinen, Dept. of Chemistry and Chemical Engineering, University of Illinois, Urbana, Ill.

Experimental techniques suitable for electrochemical measurements in LiCl-KCl at 400°—500° are emphasized, with a discussion of the problems involved in extending the techniques to higher temperatures and to other solvents. Solvent purification, introduction of reactants, preparation of micro-electrodes, reference electrodes, liquid and membrane junctions, materials of construction, etc., are included. Some inter-relationships between the type of measurement being made (*e.g.*, equilibrium potential, steady-state current, potential or current transient, impedance) and the experimental technique are brought out.

Abstract No. 140

Electrochemical Measurements at High Pressures

A. Distèche, Lab. of General Biology, University of Liège, Liège, Belgium

Most experimental data concerning high-pressure electrochemistry are obtained from conductance measurements covering a very wide pressure range (127,000 atm). Glass electrodes can be made to withstand 1500 atm and give reliable information on *p*H changes resulting from ionization shifts in buffers, acids, and weak bases. The electrode is used for deep sea (2500 m) *p*H recordings from the French bathyscaphe. Multielectrode cells for simultaneous *p*H, *r*H, and conductance determinations might prove useful in various fields.

Abstract No. 141

Electron Spin Resonance Measurements in the Study of Electrode Processes

D. H. Geske, Dept. of Chemistry, Cornell University, Ithaca, N. Y.

Electron spin resonance spectroscopy is a uniquely sensitive technique for detection of free radicals. Thus it is a helpful tool in the characterization of electrode processes. Experimental techniques are reviewed with emphasis on the intracavity electrode. Factors affecting sensitivity of detection are presented. Various nitroaromatic anion radicals serve to illustrate the detection of relatively stable free radicals in polarographic reductions.

Abstract No. 142

A New Method for the Measurement of Fast Ionic Reactions

H. Strehlow, Max-Planck-Institut fur Physikalische Chemie, Gottingen, West Germany

The reestablishment of an ionic equilibrium $A^+ + X^- \rightleftharpoons AX$ after a pressure jump of 50 atm is followed by

conductivity measurements. Thus relaxation times between about $5 \cdot 10^{-5}$ sec and 5 sec can be determined. The experimental technique and an example of an application are discussed. The mechanisms and kinetics for the interaction of Fe^{+++}-ions with different anions were elucidated.

Abstract No. 143

Instrumentation for Electrochemical Calorimetry

J. M. Sherfey, National Bureau of Standards, Washington 25, D. C.

The heat effects of electrolysis have been studied in an adiabatic calorimeter divided into two symmetrical compartments, each of which contains a half-cell. Essentially, the experiment entails the measurement of the reversible heat developed in each half-cell, and from this the half-cell entropy change is calculated. The associated electrical circuit is different from that ordinarily used in calorimetry and includes a reference probe which permits the measurement of irreversible electrolytic effects. Adiabatic control is made possible by sensitive thermopiles which can be immersed in the electrolyte.

Abstract No. 144

Modern Techniques for Determining Transport Numbers

F. R. Duke, Dept. of Chemistry and Institute for Atomic Research, Iowa State University, Ames, Iowa

During the past fifteen years there have been developed several new techniques for measuring transport numbers; in addition, there have been refinements of some older procedures. These methods depend on separation of anode and cathode compartments with a fine porous plug plus some other arrangement to prevent gravitational flow between compartments in most cases. Then a volume change, a weight change or radiotracer movement is measured as a function of charge passed, to assess the transport numbers.

Abstract No. 145

New Developments in the Measurement of Mass Transfer Polarization and Limiting Currents

C. W. Tobias, Dept. of Chemical Engineering, University of California, Berkeley, Calif.

Interpretation of mass transport measurements over extended electrode surfaces requires knowledge of distribution of transport rates. This may be obtained by simultaneous measurement of limiting currents or polarization on a suitable number of isolated electrode segments. Apparatus and technique for dynamic measurement of limiting currents and polarization are described for free and forced convection models, where the mass transfer boundary layer varies with position and time.

Abstract No. 146

Rates of Electrode Processes by the Rotating Disk Method

D. Jahn and **W. Vielstich,** Institut fur Physikalische Chemie der Universitat Bonn, Wegelerstrasse 12, Bonn, Germany

Diffusion coefficients and the kinetics of chemical reactions proceeding an electron transfer can be measured by the rotating disk electrode, evaluating limiting currents. Moreover, it is possible to measure exchange currents by determining the current-speed relation near the equilibrium potential. Thus exchange current densities up to 10 amp/cm^2 can be obtained.

Abstract No. 147

Faradaic Rectification and Electrode Processes, I. Theory

Mitsugi Senda and **Paul Delahay,** Coates Chemical Lab., Louisiana State University, Baton Rouge, La.

Fundamentals of the faradaic rectification method for the measurement of electrode kinetics parameters are reviewed as follows: types of control of electrical variable; general treatment for control of the mean current equal to zero or the mean potential equal to the equilibrium potential; effect of the double layer charging and circuit resistance; third order effects and case of an alternating voltage exceeding a few millivolts; influence of a homogeneous or heterogenous chemical process preceding charge transfer; influence of specific adsorption without and with coupled charge transfer.

Abstract No. 148

Faradaic Rectification and Electrode Processes, II. Experimental Studies

Hideo Imai, Mitsugi Senda, and **Paul Delahay,** Coates Chemical Lab., Louisiana State University, Baton Rouge, La.

Experimental verification is presented for the essential points of the theory of faradaic rectification. An installation is described for measurements in the range 50 kc to 50 Mc/sec. Generation *in situ* of one reactant is also analyzed. The following measurements are discussed: direct measurement of rectification voltage; indirect determination of rectification voltage by comparison of current-time curves for rectification and for a voltage-step; influence of cell voltage, concentration of reactants, cell resistance, double layer capacity, preceding chemical reaction and specific adsorption. A comparison is made with other relaxation methods for fast electrode processes.

Abstract No. 149

A-C Methods in Interfacial Electrical Phenomena

Akira Watanabe, Institute for Chemical Research, Kyoto University, Takatsuki, Osaka-Fu, Japan

The mechanical vibration of the electrical double layer gives rise to generation of alternating voltage. In the case of glass-liquid interfaces this effect can be used to measure streaming potentials by a-c technique, and in the case of mercury-solution interfaces it is an effect of alternating capacity current generation, which provides a new method for double layer capacity measurements. Various other methods for these measurements are also discussed in detail.

Abstract No. 150

Electrokinetic Studies with an X-Y Pulsed Measuring System

C. H. Presbrey, Jr., and Sigmund Schuldiner, U.S. Naval Research Lab., Washington 25, D. C.

The X-Y Pulsed Measuring System developed at the Naval Research Lab. by Haas and Harris was modified for electrochemical studies. By the use of a versatile pulse generator and a modified double sweep oscilloscope, a highly flexible system giving accurate control of pulse rise time, repetition rate, length, amplitude, and delay makes possible the quantitative determination of the electrokinetic parameters of fast reaction steps. An investigation of the hydrogen reaction on platinum in acid solution resulted in a quantitative separation and determination of solution resistance, charge on the double layer, and the discharge/ionization reaction step.

Abstract No. 151

Effect of Organic Molecules on the Adsorptive Properties of Platinum Electrodes

Manfred Breiter, Research Lab., General Electric Co., Schenectady, N. Y.

The effect of different amounts of organic molecules in 1*N* $HClO_4$ on hydrogen and oxygen adsorption of smooth platinum electrodes in the potential range between hydrogen and oxygen evolution, as found by impedance measurements and potentiostatic investigations, is discussed. In the double layer region the capacity decreases with growing molecule concentration on platinum as on mercury. However, no adsorption and desorption peaks of the capacity are found on platinum.

Abstract No. 152

Characteristic Functions and Parameters in the Theory of Hydrogen Overpotential

G. W. Castellan, Dept. of Chemistry, The Catholic University of America, Washington, D. C.

Three two-step mechanisms for the hydrogen evolution reaction are considered. In each case the cur-

rent-potential relation can be arranged into a compact form which is useful for the graphical interpretation of the data. A characteristic function, calculated from the data, is plotted against tanh $F\eta/2RT$. The ratio of intercept to initial slope depends on the surface coverage and a parameter ρ. This ratio is independent of the adsorption isotherm.

Abstract No. 153

Kinetics of Hydrogen Evolution at Zero Hydrogen Partial Pressure

Sigmund Schuldiner, U.S. Naval Research Lab., Washington 25, D. C.

Polarization curves for the hydrogen evolution reaction on platinum and rhodium were determined in 1M H_2SO_4 solution stirred rapidly with helium. Here the partial pressure of hydrogen gas above the solution was virtually equal to zero. Experimental results indicated that for both metals the rate-determining step in the lowest current density range was primarily the electrochemical desorption of hydrogen atoms. As the current density increased the rate-determining step changed to one that was primarily controlled by atomic combination. Kinetic equations were derived and the calculated relationships compared favorably with the experimental results.

Abstract No. 154

Effects of Electrostatic Fields on the Surface Tension of Salt Solutions

G. M. Schmid, R. M. Hurd, and **E. S. Snavely, Jr.**, Texas Research Associates, 1701 Guadalupe St., Austin 1, Texas

A high sensitivity surface film balance has been adapted to permit measurement of surface tension changes induced by the application of electrostatic fields across the surface. Preliminary measurements on saline water solutions indicate that the surface tension is lowered by up to 0.2 dynes/cm at field strengths of 7000 v/cm. Using a modified Gibbs' equation, estimates of the surface concentration changes associated with the surface tension changes have been made.

Abstract No. 155

Contact-Potential Olfactometry; Specificity and Sensitivity in Adsorption of Organic Vapors on Solids

Andrew Dravnieks, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Surface potentials of solids, measurable in terms of contact (Volta) potential differences, are notoriously sensitive to presence of adsorbed films and could serve as a means of objective olfactometry. The necessary requirements would include sufficient specificity and sensitivity of the electrical effect. Theoretical con-

siderations show that high sensitivities should be possible. Experimental data on several solid-organic vapor systems, such as potassium dichromatic-acetone and silver oxide-thiophene, give indications of the magnitudes of effects.

Abstract No. 156

Measurement of Small Surface Areas by Krypton Adsorption

Tennyson Smith, Atomics International, Division of North American Aviation, Inc., Canoga Park, Calif.

The surface area of glass sample holders (48-178 cm^2), sintered uranium dioxide pellets (69-2000 cm^2), granular zirconium and niobium beryllides (270-2200 cm^2), and small (50 mg) powder samples of UO_2, ZrO_2, CeO_2, and TiO_2 have been measured by the BET adsorption method with krypton as the adsorbate. Measurements were made rapidly (1-2 hr) with high precision (~1%) and reproducibility (~4%). All calculations were programmed for an IBM 709 computer. A good correlation was found between powder surface area and average particle diameter. A linear relation between BET surface area and rates of oxidation of sintered UO_2 pellets was found. The importance of surface area measurements for the interpretation of kinetic studies is discussed.

Abstract No. 157

Continuous Coulometric Analysis of Chlorine Bleach Solutions

E. L. Eckfeldt and **E. R. Kuczynski,** R&D Center, Leeds & Northrup Co., North Wales, Pa.

An experimental coulometric system was devised for continuously and automatically titrating chlorine bleach solutions which ranged in concentration from 20 ppm to 3%. The titrating reagent was produced cathodically, the cell current at equivalence being a measure of concentration. The special cell construction provided about $\pm 1\%$ measurement accuracy throughout the concentration range. Difficulties in holding the solution at equivalence with concentrated samples were met by means of a function-transforming circuit in the automatic control system.

Abstract No. 158

The Electrokinetic Streaming Potential as a Source of Energy

R. E. Meredith, Dept. of Chemical Engineering, Oregon State College, Corvallis, Oreg.

The electrokinetic streaming potential generated within a porous matrix may be employed as a modest source of electrical energy. Conditions and variables are discussed for maximizing the power that may be extracted from such an electrokinetic device. Although the streaming potential is theoretically independent

of the area to length ratio of the porous bed, this variable is shown to be important in determining the potential when current is drawn from such a system.

Abstract No. 159

Polarization Curves of Redox Systems Involving Consecutive Electron Transfers: Some Theoretical Aspects

R. M. Hurd, Texas Research Associates, 1701 Guadalupe St., Austin 1, Texas

An equation, first worked out by Vetter, describing the complete polarization curves for redox systems involving two consecutive electron transfer steps, has been examined in detail by computer solutions. It is shown that quite wide variations in the values of the individual transfer coefficients have little effect on the shape of the theoretical curves. However, as the ratio of the individual exchange currents approached 100:1, two definite linear-logarithmic regions appear in one branch of the curve. It is further shown that in many cases the diffusion current masks the true Tafel portion, leaving the "pseudo-Tafel" part as the only observable linear-logarithmic region.

Abstract No. 160

A Model for Electrochemical Reaction Kinetics of Solid-State Phase Transformations in Reversible Electrodes

G. T. Croft (present address: Pitney-Bowes Inc., Stamford, Conn.) and **Donald Tuomi,** Thomas A. Edison Research Lab., West Orange, N. J.

An atomistic model is presented for the reversible oxidation-reduction of a compound, MX, which separates a metal, M, from an electrolyte containing anions X^-. The electrochemical film growth is assumed to depend on the presence of lattice imperfections. The detailed mass and charge transport mechanism is controlled by the particular set of exchange reactions at the M-MX and MX-electrolyte interfaces. If cation vacancies and holes are the relevant lattice and electronic imperfections, there are four possible sets of exchange reactions. Each set and the distribution of the overpotential across each interface determines a particular electrochemical mechanism.

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